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ABSTRACT

The 43 papers in this collection were presented at the Australian Council for Computers in Education 1993 annual conference. The papers focus on research and scholarship in the use of computers at the elementary, secondary, and higher education levels. The papers address the following aspects of the use of computers in education: (1) theoretical issues such as telecommunications research, global literacy and cognitive modeling; (2) computers and special groups including the disabled; (3) specific technologies, including virtual reality, multimedia, electronic mail, hypermedia, and hypertext; (4) topical applications such as business, law, geology, geophysics, computer programming and computer simulations; (5) software packages and their uses; and (6) the use of computers in training and supporting teachers and the extent of teacher use of computers. The collection also contains a 1992 national survey on the integration of computers into the classroom. Many of the articles are illustrated with graphs, tables, charts, or other graphics, and most papers contain references. (KRN)

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EDITORIAL

Welcome to the ACEC'93 Conference issue of Australian Educational Computing. First, a thank you to all those who wrote or read these papers and thus made this issue of the journal possible. This publication marks a departure from previous conference proceedings. The Program committee decided to divide all papers received into two publications. This decision reflects our philosophy that this national conference should be useful to a wide range of educators who are interested in educational technology.

As far as possible the conference is open to all in the educational community who wish to share their experience with their peers. The conference sessions are limited only by available space. The published papers were directed into two broad streams that are of an equal standard but which address two different audiences. The Proceedings is made up of papers of a practical nature while this edition of the Journal contains "refereed" papers that report on research or scholarship. The Proceedings are intended for classroom practitioners who are mainly concerned with issues of practical pedagogy. The Journal is intended for whose who have more of an analytical perspective on Information Technology. We firmly believe that each audience will benefit from the others understandings and so all conference participants will receive both documents.

Both publications have been designed to be attractive and accessible. The covers focus on the people in whose benefit the papers might be read. These publications are meant to be used now and not put away for later reference. Ideally they will left on staffroom tables for your colleagues to pick up and browse. The bright colours might also help these publications to stand out in a rack of serials or new books in your library. In this area of education information dates very quickly. The "use by" date is not long off. Please be active in sharing these resources with your peers. Copies of the journal will be sent to libraries around the country. Additional copies will be on sale from NSWCEG at the address on the fly leaf.

This journal is a refereed journal. The review of these papers was different from the traditional anonymous process where all communication is mediated by the journal's editor. In view of the collaborative philosophy of the conference, the intended audience for the papers and the publishing timeframe, a peer review process was chosen by the Program committee. The rapidly developing nature of this area of education requires current information on innovation and research if published material is to retain any real relevance.

Following the call for papers and the receipt of expressions of interest a set of guidelines were sent to those who had responded. As part of the call for papers people who were prepared to act as referees were asked to nominate themselves to the editor. This pool of "peers" were then sent one or more of the submitted papers to review. They were chosen because of their known expertise or because of their geographical proximity to an author. They were asked to discuss their suggestions directly with the author of the paper they had read and to send a summary of their comments to the editor. A list of the referees appears at the end of this section of the journal. The papers were then revised by their authors and sent to the editor. The Program committee of myself, Leanne Samootin and Stanislaw Wawrzyniak next made final decisions as to which papers would be published and in which document it was most appropriate to publish them. We believe that this is the best way to encourage cooperative improvement in the original draft papers.

Finally I would like to thank the national editorial panel for their generosity in allowing us to use the journal for the publication of conference papers. The layout of this publication is not up to their usual excellent standard but our hope is that this special conference issue will raise the profile of the journal and encourage more of you to send more articles to them more often.

PRESIDENT'S REPORT

On the eve of the Eleventh Australian Computers in Education Conference I would like to consider an important matter with you. It is an exploration of an issue which is always with us but which is brought into clear focus at this time of the year.

The national conference is with us again and, as has become customary in recent years, it is a time to not only enjoy the fruits of the labour of our generous hosts, this year the New South Wales Computer Education Group, but also to reconsider our learned gathering and its place in the Australian educational scene. Last year in Melbourne we had spirited debate concerning the current roles and future directions of the ACEC. Had the institution of the national conference become tired and outdated? Was it too academically oriented? Had it become too focussed on technological esoterica at the expense of grassroots curriculum issues?

Should questions like these be taken seriously? Are they to be dismissed with a wave of contempt? Are they to be nervously sidestepped each year? No. In addressing issues like these we perform the necessary exercises of self examination and review - critical steps if we are to continue providing a quality service to educators throughout the country. We must continue to re-examine the nature and structure of our conferences, their impact on the educational scene and their ability to capture the *Zeitgeist* as well as provide a springboard for the future.

The national conference is conducted each year on behalf of the Australian Council for Computers in Education (ACCE) - the federation of all state and territory professional associations. A host association organises the conference on behalf of the ACCE and in doing so helps the ACCE to fulfil a number of its primary aims. (I have outlined these in my column in Australian Educational Computing Vol . 8. No. 1.) The conference is our centrepiece - our yearly chance to showcase the talents and achievements of Australian educators working with computers and related information technologies. It also exists to provide us with a window to the rest of our region and the world at large. This window works both ways. We have the chance to glimpse activities and trends from around the globe and compare them with our own circumstances, and, as importantly, we have the opportunity to show our overseas colleagues what we are capable of here.

The national conference is not meant to be an enlarged version of the largely classroom-oriented conferences and workshops that state associations run so well. Neither is it designed to be solely an academic talkfest. It should and it must provide the opportunity for educators working directly with students to examine the issues that relate to day to day concerns. As well it must be prepared to provide a forum for "big picture" debate and the airing of research findings. To have one without the other would be to either devalue the activities of the classroom or dismiss the importance of academic thought. Either of these failings is unacceptable.

My great concern is that people may start to believe that these two "major activity areas" for want of a better term, are mutually exclusive and that each has an audience that will not tolerate or appreciate the other. Are some trying to paint a picture of teachers as an unsophisticated group of practitioners only concerned with day to day survival issues ? What of academics? Do they really exist in cloistered surroundings not understanding the challenges facing those "at the chalkface"? I think not. The great majority of people I have worked with in this area over the last dozen or so years have been uniformly professional in their outlook, interested in broad issues as well as the specific, and as such have drawn benefit from all aspects of representative conferences. I make no distinction regarding the nature of their daily tasks when I judge them my colleagues. I assume that in order to best appreciate and understand the impact of information technologies on education we all must be prepared to consider and have an interest in the broadest possible range of practical and theoretical considerations.

The national conference must seek to strike a balance in its program to cater for the needs and interests of all delegates. All the conferences I have been associated with have striven to do this and I am confident that all in the future will do the same. ACEC 93 will no doubt be a fine example of the type of quality conference we are able to offer to the Australian educational scene and will provide a forum which is both enlightening and stimulating for computer education professionals - no matter where we spend our work days.

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TELECOMMUNICATIONS APPLICATIONS IN EDUCATION: A RESEARCH TAXONOMY

BY BETTY COLLIS

University of Twente
Enschede, The Netherlands

Telecommunications applications in education are the subject of many different projects, interventions, and research investigations. In this article, the domain for such applications is first defined and then a two-dimensional taxonomy for research in the domain is suggested. The taxonomy is used as a framework for hypotheses about the productiveness of different research focuses in the area. An "intermediate indicator" of increased usage of telecommunications in educational practice as a common performance indicator for different research activities is suggested and explained.

INTRODUCTION

The implications of connecting people to each other or to distant resources via technology have been research focuses in the distance education community for a considerable time, but are becoming more and more of interest throughout the broader educational community. Advances in computer and communications technologies are now making wide-area interconnectedness for communication and information handling increasingly feasible for learners and teachers. Research related to these possibilities is increasing at a rate parallel to the escalation of possible educational applications of this computer-mediated interconnectedness. The domain of this activity is still emerging and is far from well-defined.

An immediate consequence of this state of affairs is that research and experience in the area is difficult to collect and analyze. As was the case with the emergence of computer applications in education a decade (or more) earlier, researchers are multi-disciplinary in background and tend to approach the investigation area through their own frames of reference and with their own vocabulary. This also complicates research synthesis.

PURPOSES OF THIS ANALYSIS

The major purpose of this analysis is to suggest a pattern for conceptualizing research in the domain of telecommunications applications in education in order to help better integrate the many different research activities occurring in the area. After offering a overview of the domain under investigation, telecommunications applications in education, we thus develop a two-dimensional taxonomy for research activity in the domain.

Such a taxonomy should serve more than categorization purposes. Its major value should come from its application to the emergence of more-coordinated research activity in the domain area. Thus the secondary purpose of this article is suggest how the taxonomy could be applied. One such way is to help prioritize research activities; we illustrate this through a series of hypotheses relating to which types of interventions are most likely to have an impact on which types of outcome measures in the domain. Another application of the taxonomy is to suggest a global performance indicator against which the productivity of research activity in the domain can be measured. We also illustrate this possibility.

DEFINITIONS

Before we can go further, however, some definitions and delimitations are necessary. First, the awkward term "computer-mediated interconnectedness" must be defined, and exchanged for a more commonly understood term. We will limit ourselves to the subset of telecommunications-mediated applications in education in which a person—teacher or learner—sitting at his or her computer makes contact with a person or persons in other locations or with electronically stored resources in other geographically distant locations. For simplicity, we will call this domain "telecommunications applications in education."

Scale:	**Educational Purposes:**			
	Communicate	**Work Together**	**Share Resources**	**Find Information**
One-to-One:	E-mail	E-mail	File transfer, Document sharing	
Small Group:	E-mail, Conferencing	CSCW (Groupware), CSCL, Conferencing	File transfer, Document sharing	
Larger Group:	E-mail (listserv), Conferencing, BBS Forums, News items		BBS down- and uploading of files	Institutional data base
Many-to-Central Resource:	System-wide news			On-line data bases (full text or relational)

Figure 1. Educational applications of telecommunications, from a functional-technological perspective.

Figure 1 shows a conceptualization of the domain, with dimensions relating to the human scale of the telecommunications activities and to the educational function of the activities.

By this definition, it should be noticed that we have delimited the use of the term telecommunications, so that we do not include television broadcasting or video-conferencing or audio-conferencing or FAX transmission or voice mail or other such communication variations, even though of course, microcomputer technology is involved in the variations. In our delimitation, from the user's point of view, he or she is sitting at the keyboard of a personal computer.

Finally, we will focus on education broadly, to include not only school-level sectors but also higher education, professional education, training, and non-formal education. Thus we will use the terms "teachers" and "students" for simplicity, but relative to the type of educational setting involved, we realize terms such as "trainees" or "learners" and "tutors" "instructors", "instructional materials providers" or "trainers" would sometimes be more appropriate. Also those involved in telecommunications-mediated activities are sometimes the teachers and other times the students and other times both in interaction. In reference to Figure 1, for example, "small groups" could be teachers working together on a curriculum-development project, or adult trainees in a company with branches at different locations, or young students in two or more classrooms working on a common research project. "One-to-One" could be, for example, two teachers talking to each other about lesson ideas, two young learners getting acquainted with each other electronically, or a tutor and client in a distance-education setting. "Large Group" could be course members in a distance education program or could be a group of professionals, such as science teachers, interacting informally (see, for example, Ruopp, Gal, Drayton, and Pfister, 1993, for a description of the "LabNet" community).

In concise terms, then, how can we categorize research about telecommunications applications in education? How can we use this categorization to suggest a action-oriented research agenda in the domain?

CONCEPTUALIZING THE RESEARCH DOMAIN

There are many ways in which a research domain could be conceptualized. Our approach is to divide research in the domain of telecommunications-applications in education into two broad categories: one dealing directly with the educational impact of such applications and the other with strategies to (eventually) facilitate the realization of the desired impact. By educational impact, we mean outcomes or results of the use of telecommunications, in terms of educationally relevant measures. By facilitating, we mean ways to intervene in or help the telecommunications-use situation so that the desired educational results are more likely to occur.

CATEGORIZING IMPACT

How can "educationally relevant" outcomes for telecommunications applications be categorized? Although we could use the cells of Figure 1 as a framework, we believe that from an educational perspective, it is not the technology which should be the focus of outcomes but rather performance indicators related to general educational goals, thus to learning, to attitude, and to the process of education. We suggest therefore the following as focuses for measuring the impact of telecommunications use in education: impact relative to the individual student, impact relative to the teacher, and impact relative to society. This impact dimension will be the first of the two dimensions of our proposed taxonomy of the research domain for telecommunications applications in education. Table 1 shows this first aspect of the research taxonomy. Following the table, the categories are discussed in more detail.

STUDENT-RELATED OUTCOMES

Based on our analysis of the research literature (Collis, 1992a) we can expand the points mentioned in Table 1 as student outcomes into eight categories of results, although sometimes the categories overlap. Many different studies could be cited as examples of each of the categories; we list one or two per category as representative.

Categorizing the Impact of Educational Uses of Telecommunications

On Students	On Teachers	On Society
-Content-related learning (faster, more, better)	-Changes in instructional delivery	-More equitable access to educational opportunities
-General technological literacy	-Enhanced professionalism	-More flexible access to relevant educational opportunities
-Process-related growth (communication skills, information handling skills, cooperation skills)	-Increased efficiency	
-Attitudes		

Table 1

LEARNING-RELATED:

1. Content-Related Learning, where the measure is improved subject-area content learning (more, or faster, or of a higher level) than what would be likely to occur with instructional methods not involving telecommunications. (Krendl & Fredin, 1985; Riel, 1989)

2. Content-Related Enrichment, where the measure is more in terms of what is made available to the student—a richer, deeper, broader, range of learning stimuli than is likely to occur with instructional methods not involving telecommunications (Irving, 1991; Stuve, 1991). With such enriched learning possibilities, it appears to be generally assumed that students will take intellectual advantage of the enriched range of possibilities available to them and that in consequence improved learning will occur.

3. General Literacy, where the measure is improved awareness of and general facility with telecommunications-mediated applications. As with computer-literacy learning goals of the previous decade, the belief that students should acquire familiarity with the full range of socially utilized information technologies now includes expectations about telecommunications (Anderson & Collis, 1993; Underwood & Underwood, 1990). Usually, general literacy is assumed to have been achieved if the student has had some experiences in using a target technology (Anderson & Collis, 1993).

PROCESS-RELATED:

4. Improved Communication Skills, where the measure is in terms of language-use growth rather than of specific achievement outcomes and where communication in a second language is often a particular issue (Levin, 1985; Scott, 1988).

5. Improved Information-Handling Skills, where the measures again are of growth and increased maturity as well as of increase in specific skills and efficiency in the use of those skills (Bingham, 1992; Grice, Galbraith, Carss, Endean, & Warry, 1990).

6. Improved Skills in Cooperation and Collaborative Work, where outcome measures are hard to define but where it frequently is assumed that the fact of participation in collaborative activities is so likely to lead to other desirable educational outcomes that the participation becomes a goal in itself (Brienne & Goldman, 1988; Durfee, Lesser, & Corkill, 1990).

AFFECTIVE:

7. Enjoyment and Motivation, where it is assumed that increases will transfer to better learning or at least to better work habits leading in turn to better learning (D'Souza, 1992; Teles & Duxbury, 1991).

8. Other Affective Results, a diffuse category with outcomes such as increased appreciation of the scientific method or of cultural differences and similarities among fellow on-line learners (Kearsley, Hunter, & Furlong, 1992, pp. 45-62; Ruopp, Gal, Drayton, & Pfister, 1993, see in particular pp. 227-244).

Teacher-Related Outcomes. Under the grouping, "teacher-related outcomes", we see three major categories of results, again occasionally overlapping:

9. Changes in Instructional Style, where the outcome is that the teacher adopts new strategies for instructional organization and delivery (Hunter, 1990; U. S. Congress, Office of Technology Assessment, 1989, pp. 87-107). The assumption is usually that such change is desirable.

10. Enhanced Professionalism, where the outcome relates to the teacher having more professional contact with his or her peers, more access to different professional materials, more discussions with colleagues, and a broader awareness of the field (Kimmel, Kerr, & O'Shea, 1987; Riel, 1990).

11. Increased Efficiency, where the measure is that the teacher can do various educational tasks more quickly or easily or cheaply so that more time or resources are available for "quality" educational interactions. (Kearsley, Hunter, & Furlong, 1992).

SOCIETY-RELATED OUTCOMES.

Under this grouping we put outcomes relevant to larger patterns of educational opportunity. In particular we see outcomes relative to the following social perspectives:

Summary of Results from 42 Studies Relating to Telecommunications Use in Secondary Education

1 ***Content-Related***
    Eastman, (1986)
2 ***Content-Related, Enrichment***
    Cohen & Miyake, (1986)
    Bowers, (1989)
3 ***General Literacy***
    Lenardon, (1989)
    Swanson, (1989)
    Archer, (1989)
4 ***Improved Communication Skills***
    Hoffman, (1989)
    Riedl, (1986)
    Meyer, (1990)
    Renwick, (1990)
    Cohen & Riel, (1989)
    Galvin, (1987)
    Reed, (1989)
    Lemp, (1988)
    Schwartz, (1986)
    Galligan, (1988)
    Andres-Syer, (1987a, 1987b)
    Cohen & Miyake, (1986)
5 ***Improved Information-Handling Skills***
    Eastman, (1986)
    Teague, Teague, & Marchionini, (1986)
    Cohen & Miyake, (1986)
    Goldberg, (1988)
6 ***Improved Skills in Cooperation and Collaborative Work***
    Rogers, Cowick, & Powell, (1989)
    Galvin, (1987)
    Ranebo, (1990)
7 ***Enjoyment and Motivation***
    Edyburn, (1987)
    Teague, Teague, & Marchionini, (1986)
    Barden, (1989)
    Rogers, Cowick, & Powell, (1987)
    Hoffman, (1989)
    Wilson, (1990)
    Galvin, (1987)
    Andres-Syer, (1987a, 1987b, 1988)
    TERC, (1987)
    Douglass, (1990)
8 ***Other Affective Results***
    Bajard, (1989), ("Students learned that there are two sides to every issue. Students wanted to hear from the other side.")
    Vlahakis, (1990), ("Learning much about each other's cultures, to make this world a peaceful place to live.")
    TERC, (1987), ("Empower students to engage in the work of scientists and explore questions of importance.")

9 ***Change in Teaching Style***

10 ***Change in Professional Habits***
    Adam & Mackie, (1989)
    Marshak, (1989)
    Monn, (1988)
    Andres-Syer, (1987b)
    Schmidt, (1988)

11 ***Increased Efficiency***

12 ***Reducing Inequities in Educational Opportunity***

13 ***Making the Provision of Educational Opportunities More Flexible***
    Gunn, (1989)
    Moore, (1989)

Adapted from Collis, 1990

12. Reducing Inequities in Educational Opportunity, with outcomes related to reducing discrepancies in educational access and possibility caused by geography or other demographical characteristics of the potential learner (Denton, 1992; U.S. Congress, Office of Technology Assessment, 1989, pp. 135-151).

13. More Flexible Access to Relevant Educational Opportunities, in terms of time of delivery, forms of participation, and choice of activity (Cade, 1992; Longworth, 1988). This is believed to be important to increasing relevance, choice, and participation in educational activities, which in turn is expected to lead to desirable learning outcomes.

APPLYING THE IMPACT CATEGORIZATION TO RESEARCH IN THE DOMAIN

In Table 2 we reanalyse data from an earlier research summary (Collis, 1990) in which more than 30 studies relating to telecommunications application in secondary education were synthesized. The table shows that the results in these studies were more related to Outcome Categories 4 and 7 of the above list than they were to the other outcomes.

A similar analysis of 13 telecommunications projects in Dutch secondary education (Collis & De Vries, 1991) showed similar results, with the following results per category: Outcome Categories 1 and 10 (one time each); Outcome Categories 2, 3, and 4 (two times each); and Outcome Category 7 (six times). Again student motivation and enjoyment were the most frequently mentioned results.

Within these 13 kinds of impact outcomes, we can see further subdivisions with respect to educational research. In particular, we note that for each of the 13 categories, the results were more often "expected to occur" or "perceived to have occurred" than they were of measured outcomes. Many studies are a hybrid of two types of results ("expected to occur" and "perceived to have occurred"), are highly descriptive in nature, and focus on what happened in the organization and execution of some on-line activity. The assumption appears to be that the process of providing various on-line activities to students will to lead to impact goals, even if the goals are not directly addressed or progress toward them measured. Further analysis of the studies in Table 2 and the 13 Dutch projects (Collis & De Vries, 1991) showed that only six of these projects supported their results with an objective form of measured effectiveness data. The remainder based their statements of outcomes on the perceptions of the researcher or the teachers involved.

As a general summary of the impact literature with respect to telecommunications in education (see also Wellburn, 1992), we think it is fair to say:

1. There is strong expectation of substantial educational impact from telecommunications use, in each of the 13 categories suggested by Table 1.

2. There is enthusiasm for telecommunications activities among those who participate in them, particularly for communications-oriented activities.

3. Measuring the educational impact of telecommunications activity is apparently difficult to do, or considered unnecessary, in that objective measurement of educational payoff occurs infrequently. When measurement does occur, it is most likely to relate to affective variables. (Collis & De Vries, 1991, 1992)

FACILITATING IMPACT

In almost all of the studies mentioned above, as well as in many other examples, the research reports contain not only some comments about impact expectations and (perceived) outcomes, but also an analysis of what factors influenced the level of impact that was achieved. Typically, at least some of the anticipated outcomes did not emerge. Most studies then make recommendations for how subsequent researchers and practitioners can better facilitate the desired impact outcomes from telecommunications use in education. (See, for example, Adam & Mackie, 1989; Andres-Syer, 1987b; Collis, 1992b; Cohen & Miyake, 1986, and Riel & Levin, 1990). More explicitly, many research studies focus directly on what might be called facilitating factors—characteristics of the telecommunications-use situation that are of interest in that they are assumed to directly or eventually lead to better realization of the desired educational impact of on-line activities.

Thus we propose that research into these so-called "impact facilitators" has come to form a second major category of types of educational research relating to telecommunications applications in education. We will thus make this kind of research the second dimension in our proposed taxonomy of research relating to telecommunications in education.

MICRO- MESO-, AND MACRO-LEVEL FACILITATORS

The impact facilitators can be categorized in many ways. We choose not to map them directly on to the 13 categories of impact outcomes (see Table 1) but instead to use the idea of micro-level, meso-level, or macro-level interventions (see Pelgrum & Plomp, 1991, for a conceptualization of these levels). By "micro-level" we the actual on-line learning environments themselves. By "meso-level" we mean the persons, events and materials that surround the actual use of telecommunications for an educational purpose. By the "macro-level", we mean those policies and practices outside of the actual on-line use that influence that use. We next give examples of research concerning each of these levels. We will also note for each of the levels of facilitators some critical factors that form baseline conditions for telecommunications use to occur. Without these conditions being met, it is unlikely that impact outcomes will have a chance to emerge (Collis & De Vries, 1991, 1992).

RESEARCH ABOUT MICRO-LEVEL FACILITATORS.

Micro-level facilitators can relate to the software with which the user interacts while on-line, the user interface of the on-line environment, the architecture and organization of the on-line environment, and the types of information and communication available through the on-line environment. Although little has been written about the data communications software that the teacher or student uses to mediate on-line activities, some research is being done (see Soepboer, 1992, and De Vries & Collis, 1993). There is more research available about the user interface of specialized on-line systems, such as those for on-line information systems (Horton, 1990); for computer conferencing (Alexander, 1991); for "groupware" (software to facilitate the exchange and sharing of information and ideas among learners involved in cooperative tasks over a distance, see Marca & Bock, 1992); and for computer-mediated communication of the e-mail sort (Samis, 1992). In all cases, the assumption is that, through improved software, users will find it easier to use the on-line environments efficiently and effectively, thus leading to eventual increase in impact performance indicators.

At the system-functionality level, research is also being done to identify which on-line functions, organized in what ways, are most useful for educational purposes. Palme (1991), for example, has made such an analysis for computer conferencing; Doyen and Wheeler (1989) for on-line information retrieval; and Collis, De Diana, and Sterk (1992) for communication and information systems for education more generally. Again, the motivation for such research is to facilitate as much as possible the micro-level aspects of on-line use so that the user is helped and stimulated, not hindered or frustrated by the human-computer interaction involved in on-line activities.

The content that should be available via on-line access to information is also a research area (see, for example, Van Beckum & Van Der Burg, 1992). Those who favour on-line communication as the major aspect of telecommunications use are not as much affected by this issue as are those who wish to access educationally relevant learning materials from on-line sources. However, in all cases, there are issues relating to the internal management of the on-line environment, be it the human management needed for effective moderation of CMC and computer conferencing (Mason, 1991), or the management needed to maintain on-line collections of information (see, for example, Horton, 1990).

Thus considerable research is being done with respect to facilitator variables at the so-called micro-level. At the least, micro-level facilitation should relate to the following critical baseline conditions for telecommunications use:

- Communications software and the user-interfaces of on-line services should not be frustrating to interpret and use
- On-line functionality should not be poorly designed (i.e., no unexpected system crashes occur, exit procedures are manageable, on-line materials can be saved and used off-line, etc.)
- Content of on-line information should be appropriate to the characteristics of the students and curriculum
- On-line costs must be affordable
- What is obtained from the on-line use needs to appear to be worth the effort of obtaining it.

RESEARCH ABOUT MESO-LEVEL FACILITATORS.

How to better help teachers in envisaging instructional integration of telecommunications applications within the curriculum and within the confines of their teaching-delivery setting is a critical area for research at the so-called meso-level of facilitators (see, for example, Roberts, Blakeslee, Brown, & Lenk, 1990). In a multi-year evaluation study in The Netherlands, for example, we have found that teachers need considerable help in the implementation aspects of telecommunications use, even when curriculum-relevant lesson ideas are carefully worked out and made available to the teachers (Verwijs, 1993). Helping the teacher to implement a telecommunications experience with a full class of students, where only one modem and telephone line are available, and where the school computers are only accessible within the networked computer laboratory is a major concern at the meso level (Collis & De Vries, 1991; 1992). Thus instructional strategies and lesson materials that acknowledge this implementation-bottleneck scenario are necessary, but not much yet produced (see Keursten & Nieveen, 1992). Research that investigates effective ways to help the teacher in his or her preparation and execution of lesson activities involving telecommunications use is also important (Stapleton, Levin, & Waugh, 1992).

At the least, meso-level facilitation should address the following critical conditions for telecommunications use:

- Lesson suggestions and materials should be available that show examples of relevant integration of telecommunications use into curriculum areas taught by the teacher
- Teachers must be willing and motivated to try new forms of instructional activity
- Teachers must be willing and motivated to invest additional time and effort on learning to use on-line systems.

RESEARCH ABOUT MACRO-LEVEL FACILITATORS.

Even if the teacher has a manageable plan for instructional use of telecommunications, and access to attractive and reasonably easy-to-use on-line environments, there are still many other facilitators to be considered. Many critical issues relating to cost, subscription to on-line infrastructures and services, teacher training and preparation, and general provision for access to telecommunications resources in the school and preparation locale must be addressed at the macro- or system level (Collis, Veen, & De Vries, 1993; U.S. Congress Office of Technology Assessment). Personnel issues are involved with any decision to support on-line learning environments. System operators and moderators are needed, as well as other categories of support persons. Costs of access to on-line services are difficult to predict and budget but strategies must be found to support the costs. How to compensate the time needed by teachers to gain familiarity with the innovation is another facilitating issue at the macro-level.

At the least, macro-level facilitation needs to address the following critical conditions for telecommunication use:

- The teacher must be able to connect a computer and modem to a telephone connection and to make outside calls
- The teacher or institution must have a subscription to some sort of on-line communication and information service and a budget to handle connection costs
- Appropriate inservice and technical support must be available
- Strategies to give the teacher adequate time and opportunity to work on-line for the preparation of lesson materials must be found
- There must be enough flexibility in school procedures regarding computer use so that student access to on-line systems can occur.

APPLYING THE RESEARCH TAXONOMY: RELATING EFFECTIVENESS OUTCOMES AND FACILITATORS

In the previous section we have argued that the research domain for telecommunications applications in education can be expressed in a two-dimensional framework, where the 13 categories of impact indicators form one dimension and the three levels of facilitators form a second. Figure 2 shows this idea. However, it is important that the research taxonomy do more than categorize existing research, as intellectually helpful as such a categorization may be. It is also important that the taxonomy suggest applications for subsequent research. We will suggest two such possible applications in this section.

Figure 2.
Hypothesized order of influence of facilitators on impact outcomes

APPLICATIONS OF THE TAXONOMY: IDENTIFYING CRITICAL AREAS FOR RESEARCH AND INTERVENTION

One such application is to use the taxonomy as a stimulus for discussion of what facilitators are likely to have the strongest effect on what outcomes. This discussion can then be helpful for priorization of research choices, based on which outcomes are stressed within a particular situation. Figure 2 also shows this application of the taxonomy. The indications "1st", "2nd" and "3rd" within the cells of the matrix are hypotheses as to the order in which each type of facilitator may have most substantial impact on which type of outcome. The hypotheses are based on our synthesis of the research literature and our own work in the area. The rankings in Figure 2 are hypotheses based on the assumption that the minimal conditions for telecommunications use have been generally addressed.

Impact Outcome Category:	Facilitation Levels		
	Micro-	Meso-	Macro
1. Content-Related Learning	2nd	1st	3rd
2. Content-Related Enrichment	1st	2nd	3rd
3. General Literacy	?	?	?
4. Communication Skills	2nd	1st	3rd
5. Information-Handling Skills	1st	2nd	3rd
6. Cooperation Skills	2nd	1st	3rd
7. Enjoyment, Motivation	1st	2nd	3rd
8. Other Affective Results	?	1st	?
9. Teacher-Changes in Instructional Style	3rd	2nd	1st
10. Teacher-Enhanced Professionalism	1st	3rd	2nd
11. Teacher-Efficiency	2nd	3rd	1st
12. Society-Equity	3rd	2nd	1st
13. Society-Flexibility, Relevance	1st	3rd	2nd

Figure 2 has presented an hypothesized order of influence for different types of interventions, relative to different impact outcomes. Let us examine some implications of these hypotheses more closely.

MICRO-LEVEL FACILITATORS.

We hypothesize micro-level facilitators to have the strongest influence relative to the meso- and macro- levels on five of the impact-outcome categories: (2) Content-Related Enrichment; (5) Improved Information Handling Skills; (7) Enjoyment and Motivation; (10) Teacher-Enhanced Professionalism; and (13) More Flexible Access to Relevant Educational Opportunities. Why?

Because each of these is directly related to the contents of what is available on-line and how well it is organized. For Outcome Categories (2) and (13), and to a lesser degree Outcome Category (10) to occur, large quantities of attractive, timely, relevant and well-indexed materials must be easily and affordably available and findable on-line. For Outcome Categories (5) and (7), quantity is not as much important compared to the organization and structure of the information, learning materials, and communication possibilities offered by the on-line environment (Walker, Young, & Mannes, 1989). For Outcome Category (7) to occur, user-handling problems and frustrations must not occur; as simple as that.

MESO-LEVEL FACILITATORS.

We hypothesize meso-level facilitators to be of paramount importance with respect to Outcome Categories (1) Content-Related Learning, (4) Communication Skills Improvement, (6) Cooperation Skills, and (8) Other Affective Results. Why?

Because we believe that all of these outcomes are most directly connected with the teaching process, and, as has been demonstrated again and again in educational research, the teacher is the critical variable in such processes (see, for example, Collis, 1988). How the teacher organizes the learning experience and environment, the interaction between the learners and the teacher, the skill and flexibility and creativity that the teacher brings to integrating media of any sort into a learning setting—all of these we believe to be just as pertinent to the effectiveness of telecommunications-mediated activities as they are to any other media-mediated learning situation. The meso-level variables are those which most directly involve the teacher-teaching-learner-learning moment and thus will be most directly involved with student-learning outcomes.

It is arguable if Outcome Category (7) should not also be included in this meso-level teacher-oriented group of facilitators. However, we have placed it in the micro-level category because we feel that the novelty value of telecommunications may be enough at the present time to have a strong affective impact on learners even above the effect of the teacher, and conversely that badly designed and hard-to-use on-line resources will frustrate even the efforts of the excellent teacher. Similarly, we have placed Outcome Category (5), Information Handling Skills, in the micro-level category, for the negative reason that poorly-designed and poorly-accessible information materials will also defeat the efforts of even the excellent teacher in terms of telecommunications use.

MACRO-LEVEL FACILITATORS.

Finally, we hypothesize Outcome Categories (9), (11), and (12) to be most strongly influenced by macro-level facilitators. We believe that expectations about change in teachers' preferred styles of teaching or patterns of work (Outcome Categories 9 and 11) are highly context-bound. Without an institutional framework to support and value and reward and facilitate innovation in teaching and working habits, it is unlikely such innovation can take root, beyond the stray-blooming "pioneer enthusiast" (see, for example, Roberts, Blakeslee, Brown, & Lenk, 1990, pp. 139-151). And the enthusiasts are not enough to bring about change in a system; diffusion must occur and this must happen under institutional support (Fullan, 1982). Outcome Category (12), relating to increased equity in educational opportunity, is particularly a function of policy and top-level facilitation.

APPLICATIONS OF THE RESEARCH TAXONOMY: TOWARD A COMMON AND MEASURABLE PERFORMANCE INDICATOR

In addition to the use of the taxonomy to suggest priorities for types of facilitation research relative to types of impact outcomes, we see a second application. The taxonomy allows us to more easily consider the research activity relating to telecommunications activities in education as a whole, and thus suggests the value of suggesting a common "performance indicator" for the different types of intervention activities that occur in this domain. Thus a second application of the research taxonomy suggested by Figure 2 can be to suggest a common interim performance indicator against which the contribution of different facilitating strategies can be evaluated. This allows the taxonomy to contribute more directly to action research in the area of telecommunications in education. Such a common intermediate performance indicator should be measurable and easy to understand. We suggest "usage in practice", expressed in terms of an increased number of persons making use of telecommunications for educational purposes, as a useful intermediate performance indicator relative to the overall taxonomy.

Why is increasing the quantity of use of telecommunications applications in education a reasonable intermediate goal for the different facilitative strategies identified in the research taxonomy? Not because of technology push, but for at least the following reasons:

1. Without broader use in practice than is now occurring, the payoff of telecommunications use relative to educational impact outcomes may not be considered substantial enough from a system-wide perspective to justify financial resources and support.

2. Without broader use in practice than is now occurring, a market will not develop for telecommunications-related activities in education, and thus the benefits of scale and competitive supply that come with such a market will not develop. As telecommunications use requires depth and complexity of resources to meet many of its hoped-for impact outcomes (see Outcome Categories 2, 5, 6, 7, 10, 12, and 13), the lack of development of a viable market for on-line services will be a serious and even deadly blow to eventual impact.

3. Without broader use in practice than is now occurring, a critical mass of users and experiences and ideas and input into the various on-line systems will not occur, thus also drying up their potential educational value and motivational level.

4. Without broader use in practice than is now occurring, research activities in this area will appear more and more divorced from reality and the field, a perception to be fought against for many different reasons.

5. Broader use in practice implies at least the perception of impact potential among those involved in the use. It also implies that baseline conditions for implementation at the micro-, meso-, and macro-levels have been met.

Thus we have suggested a second application of the taxonomy—by superimposing over it the intermediate criterion of "Will such an intervention be likely to lead to more use of telecommunications by teachers and students?—decisions about priorities for research can be commonly grounded. Researchers coming from different backgrounds and with different perceptions of the target domain can perhaps come to relate to this common outcome.

As a final comment, we believe the "more use in practice" criterion needs to be at the short-term rather than long-term level as much as possible. Although researchers should not be pushed by technology, the rapidly increasing interconnectedness of society, especially for mass communication and information purposes (see, for example, Dertouzos, 1991, and Romiszowski, 1990), should not occur in isolation from what goes on in schools. Already the notion that information and ideas are entities to be nurtured and transmitted by the educational system is no longer much relevant to many students. We as educators may not be in control of our long-term perspective if we fail now to analyze the ways in which we operate relative to the ways in which our students are already communicating with and getting information about the outside world.

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Computers fot the Curriculum

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GLOBAL LITERACY IN A GUTENBERG CULTURE

BY AL ROGERS

Executive Director, FrEdMail Foundation
arogers@bonita.cerf.fred.org

There are important pedagogical, political, social, cultural, and economic reasons why schools should consider telecommunications technologies as learning tools. This article examines a number of these issues.

LIVING IN THE GLOBAL VILLAGE

Since Marshall McLuhan coined the term in the 1960's, few of us have truly understood what the term "global village" means. Most of us have been impressed with CNN's instantaneous global video broadcasting, but the passive medium of television gives few of us the feeling of much involvement beyond our favorite reclining chair. (For an incisive critique of the influence of television on our culture, see Postman, 1985.

Yet today, growing thousands of children in dozens of countries around the world are living the reality of the global village in personal, hands-on, interactive ways. Through the medium of networking and telecommunications technologies these students are for the first time learning to think of themselves as global citizens, seeing the world, and their place in the world, in ways much different than their parents.

Today's global networks create connections between people which span time and distance in ways the world has never before seen... and with implications which are beginning to have major political, social, and economic implications. (Toffler, 1990)

Since the days of Gutenberg, the publishing of information has been an autocratic enterprise. _Time Magazine's_" Man of the Year" for 1991 was Ted Turner, founder and owner of CNN, in recognition of CNN's news coverage of global events. Yet the fact of the matter is, the "selection" of that news is dependent upon a tiny handful of executives in Atlanta. In fact, the "information media" boil down to this: a limited cadre (or cabal?) of reporters, writers, publishers, editors, producers, and other arbiters of "news," "good taste" or "political correctness" decide what is "news," what is "important," what is "good for us," and even what is "art" and "entertainment."

In contrast to this managed flow of information, however, the global Internet of networks is giving millions of people direct access to information in ways the world has never before seen. Information of every sort flows freely, across national borders and around the world, directly from "where it's happening" to where there are "inquiring minds who want to know."

For instance, the world was electrified in August 19, 1991 by the coup d'etat in Moscow. For the first time in over a thousand years, Muscovites raised the barricades and defied the powers behind the coup. Boris Yeltsin, president of the Russian Republic, issued a decree of defiance, proclaiming the leaders of the coup to be illegal and seizing authority within the Russian Republic from the central government.

Within hours the following message containing Boris Yeltsin's decree, in both transliterated Russian and English translation, flashed around the world, directly to tens of thousands of computers on college campuses, businesses, homes, and schools:

To: NEWS.GENERAL
From: dvv@hq.demos.su (Dmitry V. Volodin)
Organization: DEMOS, Moscow, USSR
Subject: Yeltsin's decree
Date: Mon, 19 Aug 91 21:20:13 +0300 (MSD)

Please redistribute this as wide as possible the followin in stripped Russian and an approximate translation to English. It'll be fine, if this reachs world information agencies. Thank you.
Dima ukaz

PREZIDENTA rOSSIJSKOJ
fEDERATIWNOJ sOUIALISTI^ESKOJ
RESPUBLIKI

pREDPRINQTA POPYTKA GOSUDARSTWENNOGO PEREWOROTA, OTSRANED OT DOLVNOSTI pREZIDENT sssr, QWLQ@]IJSQ wERHOWNYM gLAWNOKOMANDU@J IM wOORUVENNYH sIL sssr. wICE-PREZIDENT sssr, pREMXER-MINISTR sssr, PREDSEDATELX kgb sssr, mINISTRY oBORONY I wNUTRENNIH DEL sssr WO[LI W ANTIKONSTITUCIONNYJ ORGAN, SOWER[IW TEM SAMYM GOSUDARSTWENNOE PRESTUPLENIE. w REZULXTATE \TIH DEJSWTWIJ DEQTELXNOSTX ZAKON NOIZBRANNOJ ISPOLNITELXNOJ WLASTI SO@ZA ssr OKAZALASX PARALIZOWANNOJ.

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pREZIDENT rsfsr b.eLXCIN

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19 AWGUST 1991 GODA
n 61

DECREE of the president of the Russian Federative Socialist Republic
An attempt of a coup d'etat was taken, the President of the USSR, who is the Commander-in-Chief of the Soviet Army, was dismissed from this post. The Vice President of the USSR, the Prime Minister of the USSR, Ministers of Defence and Internal Affairs of the USSR formed an unconstitutional body, therefore committing a state crime.
As a result of this action the activity of the constitutional executive power of the USSR was paralised.
In this situation I decree:

1. *Until the emergency Congress of the People's Deputies of the USSR is taken all bodies of the executive power of the USSR, including the KGB, Internal Ministry, Ministry of Defence, acting on the territory of the RSFSR, are taken under the submission of the President of the RSFSR, elected by the people.*
2. *The KGB of the RSFSR, Internal Ministry of the RSFSR, State Committee of the RSFSR on Defence Problems are prescribed to temporary execute the functions of the corresponding bodies of the USSR on the territory of the RSFSR. All the territory and other bodies of the Internal Ministry, KGB and Defence Ministry on the territory of the RSFSR immediately have to obide decrees and orders of the President of the RSFSR, the Consil of Ministers of the RSFSR, the orders of the the KGB of the RSFSR, the Internal Ministry of the RSFSR, the State Commettee of the RSFSR on Defence Problems.*
3. *All executive bodies, persons, and citizens of the RSFSR have to take immediate actions to prevent the execution of any decrees and orders of the unconstitutional Commettee on Emergency Situation.*

Executive persons, obiding orders of this commettee, are dismissed from their posts in accordance with the Constitution of the RSFSR. Bodies of the Procurature of the USSR have to immediately take actions to enforce the criminal law onto this persons.
The President of the RSFSR
B.Yeltsin
Moscow, Kremlin
August 19, 1991

This message came directly from Moscow to the people of the world... unfiltered, unedited, without the benefit of selection or "commentary," "interpretation," or embellishment. (This kind of internetworking transmission is substantially different than radio or television broadcasting, which require expensive transmitters: anyone with access to a personal computer and a phone line can accomplish the same thing as our Moscow "correspondent.)

The quality of "news" and information which flows through the global village networks can also be substantially different than what we have come to expect as "news." It becomes more personal and intimate and "real." Read this message which came out of Bosnia during the early days of the troubles there:

Date: November 26, 1991 11:22
Subject: Appeal for Vukovar

Translation courtesy of Tomislav

****

Subj: APEL ZA VUKOVAR IZ VUKOVARA !!!!!!!!!

****

How can I start a story of death and desire to live?
How can I describe millions of feelings in plain words?
How can I concentrate when a packet of death explodes nearby every few minutes?
How can I ask for help from someone whose face I cannot even imagine?
How can I ask in the name of thousands of people, and whom can I ask, when all the appeals and cries for help to stop this insane bloodshed have been unanswered?

Death has become the most important aspect of life in this devastated city. She follows us in every step; she is an integral part of every thought, of every word that is being said. Separated from our wives, mothers, sisters, and brothers; in the constant presence of terrible massacres of our closest friends; deprived from the most basic needs; degraded to the level of the cattle awaiting to be slaughtered we live in damp cellars with no electricity, running water, toothpaste, soap, diapers for the babies; with no hope of resting even for a moment, because dreams *on improvised beds are only the horrible repetitions of the cruel reality.*

Can anyone who has not experienced even a little piece of Vukovar's reality understand the bitter feeling in every single one of us? Can anyone explain to him/herself and accept us as savage reality that maybe tommorow they will not see their families anymore? In our twisted world there are no lies. There is only one truth; the truth about life. Life in Vukovar today is the fight for every doorstep, for the remains of our hopes, of a town that in the morning mist resembles the site of a Hollywood horror movie.

We are not asking for charity, we are only asking for life with basic human decency. We are asking for a chance for our children to have their children. How would the West react if 2,000 of their children were confined to damp cellars with a threat of imminent death for everyone who dares to go out; with only one skimpy meal a day and uncertainty of how long such state will persist? Can you imagine something like that in London, Paris, Washington, Berlin, Vienna?

We may be separated by thousands of miles, but are our hearts separated that much? Let us bring negotiators to Vukovar! Let anyone come up with a single argument for the war when surrounded by dying babies! Let us gather all the children that have lost their parents, whose chance to walk side by side with their fathers and mothers has forever been lost. No institution will ever be able to replace the care of the parents.

Vukovar is not just a bunch of shattered buildings; it is a live organism that breathes. Vukovar has got its own bloodstream, its life that is being taken away from it. Its flesh is being torn apart; its bones are being broken. And while the city is defending itself in a spasm, it is being attacked by people to whom it represents only a point on the map.

This message is directed to all of those who love life; to all those who can appreciate the little things that make life; to all those who have ever seen a smile of a baby; to all of those who still care...

STOP THE WAR IN CROATIA, GIVE VUKOVAR A CHANCE!

Information of all types circulates on "the net." NASA scientists, aviation professionals and hobbyists, biologists mapping the human genome, Semitic and Middle Eastern Scholars studying the Dead Sea Scrolls, musicians, dissident Chinese refugees... and teachers and their students... can all be found on line, along with the information generated by their research and activities. The implications for schools are profound.

SCHOOL IN THE GLOBAL VILLAGE

When teachers and their students are "connected" to the world, teaching and learning strategies change. The "world" becomes an indispensable curriculum resource. When students communicate with people in distant and foreign places they begin to understand, appreciate, and respect cultural, political, environmental, geographic, and linguistic similarities and differences. Their view of the world and their place in the world changes. When teachers use their international connections as a learning medium,

- Subject matter becomes current, relevant, and integrated from a multi-disciplinary, global perspective.
- Students learn about their own culture and foreign cultures, their differences and similarities... directly from their distant peers, in real, meaningful, and exciting ways
- Students consider issues that are of global concern.

Consider this simple project announcement ("call for collaboration") from a teacher in the U.S. Virgin Islands:

To: SCHL.CALL.IDEAS
From:
QJOE@VIRGINI.CERF.FRED.ORG
Date: Feb 6, 1992 13:07
Subject: Virgin Islands Geography Project

This simple geography project should suit a teacher in your building. Please circulate this call for collaboration among your geography-teaching colleagues.

Hello from the Virgin Islands in the Caribbean!

My name is Joe Quain and I'm looking for 5 (five) classes from various countries and the U.S. to participate in a simple Geo/Cultural project with my middle school (ages 12-14) geography class located on St. Thomas in the U.S. Virgin Islands.

EmailContact:
qjoe@virgini.cerf.fred.org

Length of Project - 2 weeks

DESCRIPTION OF PROJECT

At the beginning of this project you will receive two essays created by my students in the Virgin Islands. One essay will describe the physical geography of our Caribbean island and the other class essay will contain a description of our island's culture.

Two weeks after you receive these essays, you will send back two similar essays about your geography and culture, using our essays as models. These essays will also be forwarded to the other participating sites.

Virgin Islands students will then compile this information and give oral reports. We will video tape these reports and send you a copy of the video tape (in USA VHS format).

OBJECTIVES OF PROJECT

(1) Each class learns about their own geography and culture and transmits this knowledge to real audiences
(2) Students become better communicators
(3) Students conduct collaborative research culminating in the final video tape
(4) Students compare and contrasts each site's essays.

REGISTRATION

Send email as soon as possible to Joe Quain at:
qjoe@virgini.cerf.fred.org

Include your full name, voice phone number, school, district, city, country, and mailing address. Please include your grade and subject area. If more than five schools reply, I will select five classes which represent an interesting geographical and cultural diversity. I will notify all schools by February 21 regarding their selection.

TIME LINE

February 21 - Five sites chosen for project are notified on Email

February 24 - Virgin Islands Essays sent to participating sites.

March 9 - Five remote sites send Physical Geography class essay to the Virgin Islands.

March 16 - Five remote sites send Cultural description class essay to the Virgin Islands.

March 30 - Video sent to five remote locations.

ESSAY DETAILS

Physical Geography Essay - Your students will collect information regarding your own physical geography, and write a descriptive essay not to exceed 3-4 pages. This description should include information pertaining to the relief of the country or state. All significant land forms (mountains, plateaus, coastal plains, unusual features) and water bodies (important rivers, lakes, coast lines) should be described (both physically as well as utilization (economic, recreation, tourism)). The longitude and latitude should also be noted. Some information with how the physical land has influenced the history and development of your region should also be included.

CULTURAL GEOGRAPHY - TOPICS OF ESSAY CAN INCLUDE

What is germane and unique about your culture?

food/preparation, housing, music art, schools, religions, political system, dress, transportation, employment, positions or status of children, adults, and senior citizens

What are the essential cultural elements that give your locale its distinct flavor? This essay may well be longer than the first (3-6 pages).

Your students can use the models prepared by my students as a guideline for the essay which they write.

To contact project coordinator Joe Quain, send mail to:
qjoe@virgini.cerf.fred.org

Within two weeks after announcing this project, Joe had over 40 replies. He selected eight sites to join him in this project:

- Helsinki, Finland
- Tartu, Estonia
- London, England
- Amsterdam, the Netherlands
- Madrid, Spain
- Cape Town, South Africa
- Melbourne, Australia
- San Antonio, Texas.

Joe reported that this project not only accomplished his objectives in studying geography and global cultures, it also engaged and motivated his students. He also reported an unexpected dividend: his student's grammar and overall writing skills dramatically improved as they corresponded with students who spoke English as a second language and sought to "coach" them in improving their English.

NETWORKING AND PROJECT-BASED LEARNING

The lingua franca of email and computer conferencing (electronic text) is the written word. Although the input device (keyboard) is new, the mode of expression (written language) is thousands of years old. In today's "reach out and touch someone" age, millions of people who would never put pen to paper to write a letter will spend evenings writing to dozens of people through their online connections. Electronic mail has given new life and new meaning to a profoundly traditional form of communication. Telecomputing may in fact be the last frontier of written literacy available which will incite students to traditional literacy skills.

The process writing movement has had an important impact on the way that writing is taught in schools across the nation. Researchers such as Donald Graves (1983), Donald Murray (1985), and Lucy Calkins (1986), and such programs as the Bay Area and National Writing Projects all agree on the importance of audience: give children a sympathetic audience, something of value to write about, and help them to find their voice, and they will become eager writers.

Telecomputing offers an efficient, effective means of finding and using many interesting and varied audiences for the exchange of various student activities. Furthermore, the activities can be embedded in other content areas, such as science, math, geography, history, current events, and other topics... providing an ideal environment to facilitate pwhat is becoming known as "project-enhanced" learning (Ruopp, 1993)

Joe Quain's geography project was successful because his students were engaged in activities which had rational, meaningful goals that made sense to them. Their research, writing, and communicating was directed at a specific audience with a specific purpose in mind. This illustrates a simple but powerful example of "project-enhanced" learning.

According to at least one study, the effect of this kind of approach to learning is significant. Cohen and Riel (1989) concluded that when students write for a distant audience of their peers,

- They are more fluent
- They are better organized
- Their ideas are more clearly stated and supported
- Their content is more substantive and their thesis is better supported
- They consider the limits and needs of their audience

We also have abundant anecdotal reports from teachers who testify to the effects of collaborative projects on student learning:

- They enjoy writing more
- Students are more willing to write, proofread, revise, and edit their work when they are writing for a distant audience.
- They are more careful about their spelling, punctuation, grammar, and vocabularies.

This letter we received from a teacher in Rhode Island regarding one of our FrEdMail projects illustrates this point:

Ppath: bonita2!nsutherl
From: nnnnnn@cat.cis.brown.edu)
To: fred@bonita.cerf.fred.org
Subject: letter of thanks from 3rd graders at Newport, RI

FrEd,

The following letter was written by 3rd graders at Underwood School in Newport, RI.... The Geogame provided a GREAT example of what types of learning experiences exist on the INternet for kids.

A footnote to the letter was written by the teacher of this class. I think her closing statement summarizes the feelings of all of us who participated in the Geogame.

Thanks again to you for all of your good work !! ;-)

Forwarded message:

From: mmmmmm
Subject: using computer connection
To: oooooooBrown.Edu
Date: Fri, 22 May 92 15:48:05 EDT

Dear ooooo,

We are writing to tell you that we really enjoyed the computer connection to Brown. We had a great time and couldn't wait to work on it every day.

We learned so many things like different things about our country and Europe. We also learned about latitude and stuff like that. We used big maps, road atlases, social studies books, P.C.USA program, childrens atlas', encyclopedias, wall maps and our brains. Roger, who is a sp. ed. student that worked with us on Geogame says that it made him feel like we're the smartest kids in the whole world!!

It was so much more fun than just using our books and maps and it was neat to get mail from other classes each day. We are now in the process of writing to the other schools across the country and Europe that we played Geogame with. We're learning so much from each other. We got to know one class so well that we invited them to our school so that we can meet each other and have lunch together.

Please let us do this again!!!!! Thank you so much for letting use the computer connection!
From the great third grade at Underwood School!!!!!

Dear oooo,
The children in my class compiled the letter above in their own words and typed it to you on the computer. I think you can hear their enthusiasm in their words. What I wanted to share with you though is, that if you were able to see the enthusiasm, the cooperative learning and the growth in these children during the weeks that we used your connection, there would be no question that this type of program should be accessable to every classroom.

I have a wonderful group of children that love school and love learning but I have never seen the level of motivation in them as I did in the use of this service.

I can't thank you and the people at Brown, enough for your patience in teaching us how to get "on line" and for allowing us access to such an exciting program. You helped us to do great things in educating our students. If there is anything that you can do to continue a program of this nature in the future, please don't hesitate. If anyone has a hesitation, just tell them to come to our room and see first hand the positive learning experience that this has been.

Thank you for everything. You've done more than you know!
sincerely, nnnnn gr. 3, Underwood School

Similar stories about student involvement and achievement percolate through the online networks:

- The Global Grocery List stimulates a discussion with Japanese students who are surprised that their diet staple, rice, is so much more expensive than in other parts of the world. Students in Japan and America discover principles of protectionist trade policies.
- Students in Europe and America find out from children in Israel what a SCUD attack is REALLY like.
- Students in Southern California learn from children in Santa Cruz, California, what they need to do to prepare for an earthquake... lessons learned from bitter experience.
- A student in Cold Harbor Springs, New York interviews Russian Jewish immigrants in Brooklyn. He recruits online acquaintances in Moscow and Jerusalem to interview Russian Jews in those places, and send him the results, so he can compare the stories from all three places in his high school sociology project.
- Students in New York collect relief supplies to send to their online friends devastated in the Florida hurricane.

There is no question that curriculum will change as more and more schools join the net. Students who have the opportunities described here have already begun to make their own paradigm shifts regarding their place in the world, and how to relate to it. As the global market economy grows, these students as adults will have advantages in their experience and mindset over those who were isolated to their own classrooms and communities.

The only question left, then, is when will you join the Global Village?

For more information about FrEdMail and SCHLnet, send email to fred@acme.fred.org.

End Notes

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You can upgrade it

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You can afford it

A Macintosh LC II now costs under $2,400. So the computer that's built for schools is priced for schools, too. For more information, contact Chris at 008 025 355 for the location of your nearest Apple Education Reseller.

Dedicated to learning.

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INCREASING SELF ESTEEM AND CREATIVITY OF PEOPLE WITH A DEVELOPMENTAL DISABILITY THROUGH THE USE OF COMPUTER TECHNOLOGY

BY GREG ALCHIN
N.S.W Department Of Community Services

The aim of this single case investigation paper is to examine the effects Computer Technology has on increasing the self esteem and creativity of people with a developmental disability. Previous studies in the area of increasing Self esteem and/or creativity have had mixed results mainly due to the process used ,which was mainly stuctured lessons. Work by Grinder and Lowenfeld highlighted the need for an individualised approach based on the needs of the learner.

Previous studies in the area of increasing Self esteem and/or creativity have had mixed results mainly due to the process used ,which was mainly stuctured lessons.

Work by Grinder and Lowenfeld highlighted the need for an individualised approach based on the needs of the learner.

The use of computer Technology in particular computer based drawing programs such as KID PIX provides an appropriate environment for the person with a developmental disability to take control.

"It is one of my deepest innermost convictions that wherever there is a spark of human spirit - no matter how dim it may be - it is our sacred responsibility as humans, teachers, and educators to fan it into whatever it conceivably may develop ...... We as human beings have no right whatsoever to determine where to stop in our endeavours to use all our power to develop the uppermost potential abilities in each individual. We all are by nature more or less endowed with intrinsic qualities and no one has the right to draw a demarcation line which divides human beings into those who should receive all possible attention and those who are not worth all our efforts. One of these intrinsic qualities is that every human being is endowed with a creative spirit ...... one of the 'basic drives', a drive without which we cannot exist." Lowenfeld 1957 pp 112 .

Nearly 40 years later Lowenfeld's comments still stand as a goal to be reached.

Whilst the changes in philosophy and service provision to people with a developmental disability over this time are laudable, there are significant deficits in our efforts which need to be addressed.

Considerable resources and energy have been devoted to 'the basics' of literacy and numeracy and to functional life skills.An examination of Department Of School Education curriculum guidelines for students with severe levels of disability and Department of Community Services ISP Individual Service Programs) system clearly demonstrates where the focus has been. Efforts in the area of increasing self esteem and creativity in people with a developmental disability seem pale in comparison.

The reasons for this imbalance are unclear, but what is clear is the need for an understanding of the power of self esteem and the role it plays in the way individuals learn by service providers whether they be teachers, carers or workshop supervisors. New ways of increasing self esteem need to be found.The role that computers can play in redressing this imbalance needs to be examined as a possible key breaking the locks of low self esteem.

The power of one's self esteem/concept on one's ability to perform skills and interact with the wider community is widely documented. Examples of this relationship are commonly displayed in the popular press as sporting personalities having a 'slump in form'. They have the skills but the confidence is lacking. With self confidence comes the ability to tackle new challenges, take risks, think and act creatively, thus extending one's potential.

This paper will attempt to highlight the significant relationship that exists between an individual's self estteem and their ability to think and/or act creatively, further how computer technology may offer people with an intellectual and/or physical disability the opportunity to discover their creative potential and increase their self esteem. It is important to note that this is only a preliminary single case investigation and that further research is needed in this area.

To ensure that the thrust of this discussion is not lost in misinterpretations of key terms it is essential that they be defined.

Maslow (1971) as quoted in Yau (1991) defined primary and secondary types of creativity. Primary Creativity was defined as that "which comes out of the unconscious, which is the source of new discovery - of real novelty, whilst secondary creativity is defined as the natural, logical productivity displayed in the behaviour of well adjusted mentally healthy individuals." pp 158. The successful integration of both primary and secondary creative processes defines the essence of true creativity. Work by Fran 1955 and Rogers 1959 is consistent with this definition.

Self image or self esteem is in essence self evaluation. That is what a person thinks about themselves. It is important to note that self evaluation is based upon Perception. That is how we perceive important others perceive us.

Yau (1991) states, "One's self image serves as the organising filter through which one perceives their work and others. It colours everything one sees. It screens one's experiences and determines what meaning one takes from them. Self image is not only one's frame of reference but the cornerstone of one's personality." pp155

Yau (1991) identified the relationship that exists between self esteem and contrasts in the mental state and motivations of behaviour. Further more she identified a high correlation between the personality characteristics of individuals with a high self esteem and a creative and productive personality as can be seen in Appendix 1 (Charts 1 - 3). This has been reinforced by Stasinos (1984) in referring to work by Fromm (1959) and Guildford (1950) when he states "Creative individuals tend to display strong self acceptance and positive self evaluative behaviour." pp 117

If this is so for the general population, what then of people with developmental disabilities?
Further, if there is agreement that all individuals, no matter what their intellectual capacity, has a sense of self esteem, then what of Lowenfeld's comments on creativity?

Crutchfield 1966; Maslow 1959, Rogers 1959 all found that the ability to think creatively is present, at least potentially in almost all persons including people with a developmental disability.
These assumptions have been further confirmed by research by Getzels and Jackson 1962, Taylor and Holland 1967 when they found that there is low correlation between intelligence and creativity. The implication of this work is that it reinforces the people with a developmental disability to have a creative potential.

If it is accepted then, that people with a disability have a sense of self and a creative potential, then why is there a significant public perception that people with a developmental disability have low self esteem and no creative potential? Further, what can and is being done to rectify it and what roles do computers play?

There have been numerous studies on the general population which indicate that creative potential can be enhanced through systematic classroom experiences in creative thinking activities. (Britton 1968, Callahan 1973, Covington & Crutchfield 1965) However, Stasinos 1981 states that "very few intervention studies in creativity of people with disabilities suggest that their creative potential can be improved through systematic training involving creative thinking activities".pp 130

This is not to say that creative performance cannot be increased for Rouse (1965), Stasinos (1981), Ladner (1971), Ross and Ross (1973) demonstrated that the use of Brainstorming as a teaching tool, provided a solid base in "learning by doing" and that significant increases were shown in verbal and non verbal scores. So it would seem people with disabilities have a creative potential that can be developed; the key is using the right approach.

Grinder (1991) highlights the need to understand the way in which the learner inputs, processes and outputs information. Understanding an individual's learning style is an important part of the process of providing appropriate experiences to be discovered. To not take an individual's learning style into consideration is setting up that person for unnecessary failure.
Previous work by Raise, Stasinos and Ladner whilst acknowledging the importance of "brainstorming and learning by doing" failed to take into account the persons mode of learning and the need to attach meaning and purpose to the creativity training.

Matson's (1991) work further provides direction. Matson's work on creativity saw the importance of having a meaningful project to work with the validity of failure. Validity is used here in the sense of learning from one's mistakes. He argues that instead of rewarding success, we should be rewarding failure or more to the point intelligent failure or risk taking. As Matson states you need failure to define the boundaries of success. The implication of this belief is that there is in many cases more than one right answer to a problem, and that trial and error, exploration and discovery are just as important phases as mastering the skill itself. The process therefore is just as important if not more so than the product.

For people to feel comfortable and secure in taking risks and dicovering their potential there is a need for rapport between 'the learner and the teacher'. The key as Lowenfeld states is "the establishment of rapport .... this feeling of empathy is one of the most important pre-requisites to success"pp 115 .

Part of gaining rapport with the person is to have not only an understanding of the nature and degree of the persons disability and how that person reacts to it but of their mode of learning as outlined in Grinder's (1991) work on Neuro Linguistic Programming. How the person learns is a variable which cannot be overlooked or understated. To not foster it can seriously effect one's effort to support a persons chances of achieving success.

Lowenfeld's (1957) work in art therapy clearly demonstrates the value of art as a medium in which to nurture self esteem and creativity. Lowenfeld believed that people with a disability "not only gain self confidence through their own creative achievement ... and ... often derive from it a great deal of independence and achievement so badly needed by them" pp 115. Once rapport has been gained then the educator can aquaint their client with the art medium to be utilised and the creative process.

Lowenfeld's work in the late 1950's focused on the use of traditional art media to allow individuals to express how they perceived themselves and their relationship to the environment in which they interacted. In being constrained to using only traditional media many individuals would due to the nature of their disability have had their opportunities and boundaries for success limited.

Now in the final decade of the Twentieth century, computer technology has significantly broadened the boundaries and opportunities for sucess. The processing power of current desktop machines allows for sophisticated images to be generated, adapted and created simply and quickly.
Further the wide range of alternative input devices ensures that an individual's level of physical disability is no longer a barrier to expression in the fullest sense.

The power of computers and the choice of multi-sensory interactive software provides the opportunity for people with a developmental disability to increase self esteem and creativity in a way unavailable in other more traditional approaches.

Piper 1988 identified a range of factors which highlighted the value of computers as a tool for teaching functional skills and increasing self esteem. Some of these were:

1 Being in control of a sophisticated piece of technology which was socially valued gave individuals a sense of importance.

2.The non threatening and judgemental aspects of computer aided learning assisted in the development of a positive and secure environment in which to work.

3.Motivation, attention and concentration spans could be increased using multi sensory/modality feedback of computer based drill and practice.

4.Greater control of the learning situation could be achieved by the use of well designed software.

5.Thinking and problem solving skills could be enhanced.

6. Use of alternative input devices and the ability of software programs to be individualised allowed persons with a range of physical and communicative disabilities the opportunity to interact as equals with their peers be it for instructional or recreational purposes.

Well designed computer software which allows for brainstorming and experimentation and is presented in a range of modalities ie is multi sensory, provides the vehicle by which self esteem and creativity can be increased. One such program is Broderbund's KID PIX's drawing and communication package which is available on MACINTOSH, IBM compatibles and ACORNS.

The other key factor is the rapport between the educator and the learner as discussed earlier.

The research question, then, is can a person with a developmental disability increase their self esteem and creative ability through successfully mastering Graphic focused computer programs as a means to express oneself.

METHOD

SUUBJECT

The subject was a female aged 8 years (Kelly) who has been assessed with a moderate level of intellectual disability. Kelly has no physical disability.

SETTING

A Department of Community Services office. (It is important to note that Kelly had visited the setting on previous occassions and felt at ease in the surroundings.).

APPARATUS

1.Personal Computer

At the time of intervention an Apple Macintosh LC with 12" RGB Colour Screen with image writer II and colour ribbons was used. As KID PIX is available on 3 different platforms any configuration could be utilised.

2.Computer Software
a)Games
b)Creativity Program - titled KID PIX
c)Personality characteristic checklist

PROCEDURE

1. Develop rapport with the person. This involves getting to know them as a person sharing recreational activities ie playing computer games.
2. Undertake baseline of personality characteristics.
3. Demonstrate 'KID PIX' program.
4. Client experimentation with program. Asks questions/prompt. What would you like to add now?
5. Printing or artwork/printing.
6 Display of artwork/printing.
7. Observation of personality characteristics.
8. Repetition of steps 4-7 until mastery is achieved (needs no prompt on using tools).

NB:

It is important to note that there is no specific time frame given for the procedure. The reason for this is it is inappropriate to quantify a figure. What is important is the PROCESS.

DATA ANALYSIS

The checklist of observable characteristics was implemented through incidental observation. The higher the scoring of characteristics the higher the self esteem and creative potential. This will be implemented at the beginning and end of each session and on mastery of the program.

The complexity and type of work developed by Kelly was the other form of data collection. Changes in style should occur as mastery grows. This should provide an appropriate level of reliability/validity.

DISCUSSION

Examination of the results charted in Fig 4 shows a growth and/or strengthening of personality characteristics as Kelly developed proficiency and mastery was finally achieved. Concomitantly there is corresponding development or growth in the artwork she produced.

As proficiency increased prompts were faded out. In fact prompts were no longer necessary after the second session.

There was a dip of perceived personality characteristics on the second attempt before a gradual rise to mastery. Reasons for such a trend is because of the high result at the end of Session 1 which it would seem is due to the excitement of additional attention and having access to the computer. At Kelly's school there is only one computer in the classroom, and gaining access to it at school is 'a reward'. The drop in Session 2 can be explained by frustration at realising the capability of the program but not being fully aware of how to utilise it.

Finally, as Kelly's proficiency increased her desire to try other programs has increased also.

Examination of Kelly's artwork (Appendix 2) shows a noticeable increase in complexity and also connection to her environment as Kelly's skills at using KID PIX increased.

This growth in complexity and connection to the local environment is consistent with that of changes in development as outlined by Lowenfeld.

PERSONALITY CHARACTERISTICS	BASELINE	S1	S2	S3	S4	S5	POST TEST
Greater need to be alone	2	3	2	3	3	2	2
Courage	2	2	2	2	2	2	2
Openess to experience	2	3	2	3	4	4	4
Trust of one's intuition	2	3	1	3	4	4	4
Spontaneous ability to be childlike		3	4	4	4	4	4
Unusual task committment	1	4	2	3	4	4	4
Attraction to the unknown and the mysterious	3	4	3	4	4	4	4
Tendency to be flexible and exploring		2	3	2	4	4	4
Self confidence	2	3	2	3	4	4	4
In control of one's life	2	2	2	2	2	2	4
More freedom from inhibitions		2	3	2	3	4	4

SCORING TABLE

4 - PERSONALITY TRAIT WAS ALWAYS OBSERVABLE	**(> 75% of time)**
3 - PERSONALITY TRAIT WAS OFTEN OBSERVABLE	**(> 50 - < 75%)**
2 - PERSONALITY TRAIT WAS SOMETIMES OBSERVABLE	**(> 25 - < 50%)**
1- PERSONALITY TRAIT WAS RARELY OBSERVABLE	**(0 - < 25%)**

CONCLUSION

Whilst these results are only from an exploratory case study, I believe there is much to be gained from conducting wider scale research in this area.

Many parents, educators and carers hold a perception that people with an intellectual disability prefer, even require, a high level of routine to cope. It is important to note that there is nothing intrinsically wrong with routines; indeed most of the general populations lives are based on routines. What is of concern is the level of routine and CHOICE and CONTROL we have over it, compared to that of people with an intellectual disability. (For some there is a fine line between routine and boredom).

As Lowenfeld stated we have to continue to strive to empower the lives of people with disabilities. Computer Technology offers a key to empowering people. It has been widely documented as a facilitation of learning 'basic skills', so why not basic drives and needs; creativity and self esteem?

A computer driven by quality software like KID PIX provide people with an environment that is multi sensory, non judgemental, patient, empowering and fun? Such an environment, which the individual has choice and control provides the breeding ground for exploration and innovation and thus growth in creativity and self esteem.

Appendix 1
CHART 1

Contrasting Motivation of Behaviour in Person with Positive Self Esteem Versus Person with Negative Self Esteem

Positive Self Esteem	Negative Self Esteem
Behaviour motivated by	**Behviour motivated by:**
Mental health	**Neurosis**
Rationality	**Irrationality**
Self confidence	**Self doubt**
Trust	**Fear**
Desire to achieve happiness	**Desire to minimise pain**
Desire to use one's consciousness	**Desire to escape one's**
to the fullest - sees life as a	**consciousness - sees**
series of challenges	**strategies to withdraw from life**
Challenges	**Defensive mechanisms**
Confidence and openness	**Distrtiono, reression and**
- coping reaching out	**and evasion**
inviting life's challenges	**Fear that one is inadequate**
Love of self and existence	**and unfit for existence**

CHART 2

Opposing attitude or Mental State of Persons with Positive Self Esteem Versus Person with Negative Self Esteem

Positive Self Esteem	Negative Self Esteem
Behaviour an expression of:	**Behaviour an expression of:**
Psychological maturity	**Arrested or stunted devel-**
independent thinking based on	**opment passive, uncritical,**
deliberate thought processes	**acceptance of others' ideas**
Personal choices that lead	**Personal choices that lead**
to integration of personality	**to disintegration of**
and personal health	**personality and neurosis**
Perception of reality based on	**perception of reality based**
clarity, intelligibility and	**on confusion, unintelligib-**
understanding	**ility and bewilderment**
A state of control in one's	**A state of helplessness and**
life	**chronic anxiety**
A life that has direction and	**A life that lacks direction**
purpose and specific goals	**and purpose and productive**
	goals

CHART 3

Personality Characteristics Shared by High Self Esteem and Productive, Creative Individuals

Ego strength
Greater need to be alone
Courage

Openness to experience
Trust of one's intuition
Spontaneous ability to be child-like
Unusual task commitment
Attraction toward the unknown and the mysterious
Tendency to be flexible and exploring

Self confidence

In control of one's life
More freedom from inhibitions

Internal locus of evaluation

Self acceptance & self awareness
Independent thinking
Openness to the subconscious
Intrinsic motivation in one's work
Need for freedom
Attraction for complexities in ideas, relationships
Acceptance of conflicts and ability to resolve opposites into integrated wholes
Seeking self growth and self-fulfilment
Ability to risk-take
Tendency to be excited by life and challenges

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VIRTUAL REALITY: EXPLORING THE POTENTIAL

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No computer technology has caught the public's eye more in recent times, than that of Virtual Reality (VR). It has been touted as the technology of the future, as the stuff dreams are made of, as permitting the visitation of alternate worlds, in short as revolutionising the ontological and epistemological bases of reality itself. But what is VR in reality? This paper defines the technology, reviews the recent literature, and presents some of the educational possibilities. It concludes by arguing that what is most deficit is hands-on experience with the hardware of VR. Once fulfilled, the imperative becomes that of ideas which will enable VR to reach its full potential.

INTRODUCTION

Barely a week passes without some mention in the media of VR. It is newsworthy for the likes of the news, current affairs programs, Beyond 2000, computer magazines, film reviews, newspapers, hi-fi magazines, commercials for confectionery, and Playboy. (Surprisingly the academic community has been slow to jump on the VR bandwagon). VR was of negligible interest to the media before 1989 with the main thrust coming in 1990. VR can be thought of as *fin de siècle* for the nineties: it is simultaneously fashionable and dangerous. Containing elements of psychedelia, alternative lifestyles, and virtual sex, VR poses a real challenge to academia, in particular educators, who are constrained by hardware costs, whilst a rapacious corporate sphere concocts its next marketing plan.

Krueger (1991: xiii) states that the actual term "virtual reality" was coined by Jaron Lanier, the managing director of VPL Research Inc, a company which up until recently sold high-tech VR hardware. Lanier used the term VR as a catch-phrase to describe a whole range of "virtual" things, such as "virtual worlds", "virtual cockpits", "virtual workstations", "virtual environments", and "virtual memory". It is salient that the term itself was coined by the head of the corporation which held the patents on many of the hardware accoutrement of VR research, such as the Dataglove and the Eyephones. Hence typically:

> "VR refers to three-dimensional realities implemented with stereo viewing goggles and reality gloves"
> Krueger (1991: xiii)

A more general definition comes from Sherman and Judkins (1992) who stress the immersive nature of VR:

> **"VR allows you to explore a computer-generated world by actually being in it... It has three components: it is inclusive, it is interactive, and it happens in real time.** That is to say you become part of the world, you can change it, and the changes occur as you make them." Sherman and Judkins (1992: 17)

A related term, "Artificial Reality" was coined by Myron Krueger in the 1970's to cover his own Videoplace art technology (2D interactive video images) and the 3D head-mounted viewing technologies of Ivan Sutherland. In the nineties "artificial reality" mainly refers only to Krueger's artistic works whereby video images are computer controlled and projected large so that the participants may interact in novel ways - with each other, and with computer-generated objects and creatures. However Krueger does not exclude the use of wearable technologies such as gloves, 3D goggles and reality suits.

Yet another term, "Cyberspace" is often confused with VR - Rheingold (1991), uses the terms synonymously - but is in fact a term invented by science fiction writer, William Gibson in his novel, *Neuromancer* (1984) to describe the "consensual hallucination" of the worldwide digital network into which the hero directly jacks his nervous system. In the novel, the "Matrix" was the repository of all the world's data and bears some resemblance to the Internet, the Unix-based computer network that links the majority of the world's tertiary educational institutions and high-tech organisations.

The popular literature concerning VR is small and highly descriptive. Rheingold (1991), Sherman and Judkins (1992), Aukstakalnis and Blatner (1992), Pimentel and Texeira (1993), and Wooley (1992) have authored books which usually overview the technology, chronicle its development and warn of its misuse. Research articles by Lowenstein and Barbee (1990), Schreier (1990), Allen (1991), Lewis (1991), Trotter (1991), Fritz (1991), Wright (1991) and Peterson (1992) have likewise appeared under different disciplinary guises but have also mainly highlighted the existence of VR and its potential applications. Whilst the military has been using virtual cockpits for many years, there has been little published primary research to date, on the effect of VR technologies in the classroom.

A BRIEF HISTORY OF VR

It is highly contentious as to what constitutes the beginning of VR. According to Rheingold (1991) and depending on your exact definition, it can be said that the origin of VR started in prehistoric times when ancient shaman used caves and labyrinths to induce altered states of consciousness in their disciples; when paintings and sculptures were created which depicted metaphysical beings and supernatural forces. Virtual world remnants can be found at Lascaux and hundreds of othersites across the planet, including Australia. Whether the experiences of tPalaeolithic neophyte can be likened to that of a be-helmetted VR aficianado is one of considerable conjecture.

Other possible beginnings of VR include: David Brewster who in 1844 invented the stereoscope; Duhauron's anaglyphic photographic process (1891) whereby red and green images are used to give the sensation of depth; the first 3D movie aptly called *Bwana Devil* (1952) began a spate of such movies; the birth of computing, ENIAC in 1946; papers by Englebart and Licklider in the fifties which were blueprints for modern day VR technology; and the science fiction writer, Hugo Gernsback who in 1963 conceptualised future virtual realities. And Ivan Sutherland, the father of computer graphics who designed the world's first graphics program in 1962, and the first head mounted display in 1965. Before the 1960's computing was seen purely as the processing of data, computers were number crunchers. Sutherland changed forever the potential of computing by launching CAD one of the main industrial drivers of VR in the nineties.

EPISTEMOLOGY, COMPUTER LITERACY AND PEDAGOGY

Whilst the published research on VR and educational theory is virtually (sic) non-existent, Piaget's "constructivism" (1973), Vygotsky's social vision theory (1978) and Seymour Papert's "constructionism" theory (1980, 1992) have been cited as some of the theoretical underpinnings of contemporary research in using computers to facilitate children learning mathematics (Harel, 1991). VR could just as easily be grounded by such theory.

Piaget's cognitive stage theory states that the child develops intelligence by experience with the world, via spontaneous and individual progression. VR would presumably enable the creation of new worlds to experience and navigate leading to new varieties of cognitive and intellectual development.

A feature of Vygotsky's model is the effort to show the importance of the active, vigorous learner at every stage of growth of the child. Mastery of the environment is accomplished by use of "auxiliary stimuli" which lead to immediate and challenging situations necessitating interactive reactions with a range of activities. Language, cultural artifacts, the child's own body and the ingenious use of any resources as playthings are examples of this need. The interactive and immersive nature of VR is perfectly sympathetic to this Vygotskian model.

Papert's alternate epistemology of education is significant insofar as his theory almost guarantees the use of computers as more than mere tools. In the Introduction to the book, "Constructionism" he delineates the difference between instruction and constructionism, by stressing that the traditional telling model should be supplemented by learning by making and doing, by having children actively engage in the dissemination of knowledge. Papert argues that computers, programming (and presumably VR) serve the child admirably as methods of active participation and dialogue with both mentors and the actual education process itself.

The use of 3D graphics has been investigated by Sachter (1991) who developed children's spatial knowledge using a 3D graphics package. Fifth grade children performed both structured and play tasks in virtual space. She found that children improved in their ability to solve spatial problems both on the computer and in the real world. Improvements were also recorded for spatial concepts seen in the language chosen to describe space, drawings of 3D space, understanding of Cartesian geometry, and the ability to coordinate objects and view transformations. One of the most interesting findings was the fact that on pretest measures, girls rated lower than boys, however posttests showed no significant differences with respect to gender.

The value of computer literacy has been questioned by several educators. Stevenson (1985) highlighted the duality of "literacy" as both functional knowledge and as communication skills which has fuelled the debate on computer literacy, and has focussed on what type of knowledge is necessary. Stevenson offers as an alternative, the critical paradigm. This views knowledge as more subjective, spiritual, and personal; recognizes the learner as an active participant in the production of meaning; and links the possession with the creation of knowledge. In order to empower students' learning, the only solution compatible with the critical paradigm is to treat the computer as a cultural object for critical reflection. Thus the computer has a place in the curriculum as an object of inquiry in the continual construction of social knowledge. This conclusion has special reference to VR which also attempts to construct other realities and concomitant other cultures.

Salomon (1985) investigated the gap between the learning potentials that computers provide and the actual impact of computer use on learning and development. He argued that the computer's unique potential is derived in part from four basic attributes: information, symbol systems, user activities, and relations with the user. Salomon concludes that high level learning depends upon a range of factors such as volitional mindfulness, which in turn is partly determined by the materials encountered and by personal, perceptual, and attitudinal factors. Partner-like interaction (vis a vis VR) is one way that such mindfulness can be facilitated.

Pea (1986) considered the possibilities of using computers not only to enhance, but to reorganise children's thinking and mental functioning. Pea analysed several examples of software as cognitive technologies, outlining the advantages of the reorganiser approach. It is argued that since the cognitive technologies we invent can serve as instruments of cultural redefinition, educational goals need careful selection in terms of their inherent values. What is required is an "activist" research paradigm for simultaneously creating and studying changes in the processes and outcomes of human learning with new cognitive and educational technologies (especially VR.)

Emihovich and Miller (1986) reviewed how computers are currently being used and studied in the schools. They stressed the ways in which computers will be used to enhance learning and development, and the need for research on computer learning to consider the multi-functional uses of computers in various contexts, instead of seeing it as a medium with a single effect on learning. The authors used Logo with 1st grade children as a learning test-bed and argue that any research on computer usage needed to employ a multi-layered approach accounting for: (1) value questions concerning learning content; (2) the social context in which computers are placed; and (3) theoretical principles explaining the process of learning with computers. The possibility of employing VR systems in the classroom should invoke serious re-valuing of these and other issues.

Salomon et al (1991) again stress the interactiveness of the technology, concluding that computer technology, in a similar manner to older technologies such as writing, augments its potential for enriching intellectual performance when the individual is consciously engaged in the mind-machine partnership. They state that some change in performance occurs only in interaction with the "tool", whilst other change is more global and longer lasting. VR offers the potential for the most engrossing mind-machine relationship so far.

Interestingly the NSW Department of Education Years 11-12 Secondary Syllabus in Computing Studies (1988) sees computers in terms of "problem-solving tools". This definition is but an extension of the giant calculator pre-1960 view. The syllabus takes heed of "social implications" and points to the "awareness of the interaction of people and institutions with computer based systems" (p.4). But the syllabus does not consider computers as media, as tools for creating identities and changing our world views, nor as doors to other worlds. "It (computing) is primarily concerned with the representation and manipulation of data." (p.1)

Many people view computers as alien machines, are intimidated and thus shun the technology; many people see them as mere tools to either elect to use or no. Both views miss the point that computers have irrevocably changed so many aspects of our personal and social lives: the way we write, the way we work, the way we communicate and travel; indeed the way we think about ourselves. So pervasive are computers are in our society that we fail to recognise their substantial effects on all our lives. This will not be the case with VR however. Media attention, the hardware commitment and the very obvious potential of the technology should lead to conspicuous and distinctive effects. VR will be no mere tool.

VR IN EDUCATION

Sherman and Judkins (1992: 88) report on the first use of VR in educational curricula: five groups of children, aged 9 to 15 were able to design and create virtual worlds of their own. Athough technical assistance came from the HITLab (from the University of Washington) initial predictions were wrong: the children took far less time to understand and assimilate the new technology. Working cooperatively and collaboratively the children were highly motivated; the longest duration of any group was three days. Whilst completing the project the children learned programming, networking and design. The technology had a short learning curve, kids could easily retrace their steps. It was very successful, for teachers as well as children.

Noteworthy was the finding that girls relished the process just as much as boys. Normally it is the boys who tend to favour computing and programming type subjects and tend to perform better. But the "Girls loved it... the process, rather than goal-oriented system ... they were more creative, more whimsical. They produced non-violent worlds, no blowing up of anything!" (Meredith Bricken, co-ordinator, cited in Sherman and Judkins: 89).

A school at West Denton, near Newcastle was the first European school to use VR. A virtual city was created complete with shops, streets and consumer goods. Senior high school students were able to shop in virtual French and German streets, order goods in both languages and calculate payment in francs or marks. This virtual language laboratory was in part developed by students themselves who, it was discovered, enjoyed the creation part just as much as the interaction. Other projects include a virtual factory for Health and Safety subjects, where false steps result in bricks and mortar falling all around, and a third project which looks at public places for exhibiting art works, which themselves are redefined by the VR medium.

The Canadian system, Mandala, uses video cameras in order to place an image of a person in a 3D computer-generated world. Users view themselves on an ordinary television screen, but the background can be one of several pre-fabricated worlds, which include jungles, rooms full of playable drums, ice hockey fields and so on, or one of the participant's own creation. "Hotspots" on the backgrounds can be programmed to trigger variety of peripherals via Midi signals. The participant can, of course interact with the objects around him or her by just virtually touching the hotspot.

Mandala has already been used in Ontario schools where it has been described as "stepping into Sesame Street" for elementary classes, and as a "challenging, teaching video game" for older children. It has been used to teach dance, music, rhythm, as well as more intellectual subjects as reading, language teaching, business charting, and economic data presentation.

As the basis of modern simulators, VR has the potential to affect all our jobs, especially the dangerous and physical ones. Simulators are now used to train pilots, train drivers, and fire-fighters. Virtual welding, motor vehicle driving, ship navigation, control desk work, engineering, architecture, plumbing, oil-rig work, police riot control, crisis management, first aid, and a range of medical, dental and veterinary applications are all being used at this moment.

Krueger (1991:192) proposes that children be asked to be scientists on artificial reality planets, so that they might discover the laws of cause and effect, and identify the nature of the virtual flora and fauna. The system would allow children to enter the world one at a time, in order to interact with the alien world; then they could be asked to compare notes by discussing what they had seen. Their incongruent observations would lead to a different notion of scientific observation, they would be confused, but eventually comprehend just as real scientists do.

Krueger suggests that Sesame Street characters could come to life and that words and mathematical symbols be animated so that the young child may interact with the figures and thus recognise and be at ease with words and symbols when they are again encountered on paper. Artificial reality could permit aspects of geometry, spatial knowledge and probability to be experienced first hand without the child having to come to terms with abstract concepts. Mathematical concepts such as fractions, cartesian geometry and algebra (notoriously difficult concepts) would be amenable to "concretising" using VR or artificial reality systems.

Winn and Bricken (1992) did just that by creating virtual worlds for the learning of mathematical concepts, especially "spatial algebra" (as opposed to textual algebra). By assigning x, y and z values to three-dimensional space children could interact with symbols in entirely predictable and naturalistic ways via an immersive VR system. Although this preliminary work-in-progress report does not include any pretest/posttest data, Winn and Bricken's concluding six remarks summarise the potential advantages of VR:

1. Virtual worlds are totally engaging and immersive for the student, both cognitively and affectively.

2. Interaction in the virtual world is intuitive, enabling children to naturally grasp, point and gesture.

3. Virtual worlds may be programmed to provide various levels of guidance to students.

4. Virtual objects behave in concrete ways enabling children to use their previous experience with the real world.

5. Students may repeatedly access the same virtual scene thus building on previous knowledge and understanding.

6. The system can automate some procedures leaving the studentfree to concentrate on more important activities.

THE HARDWARE OF VR

At this point in time, the hardware commitment of a VR system is the main obstacle to VR becoming a usable technology for the average person. No other potentially beneficial computer application necessitates such a large number of expensive and dedicated input devices. There are two main ways of implementing VR: as a totally immersive environment via head-mounted displays and datagloves; or as a desktop system, using the monitor to view the virtual environment, which may also include the use of gloves, special glasses or 3D mice.

Most immersive systems utilise high-end graphics workstations such as the ones marketed by Silicon Graphics Inc and costing between $20,000 and $200,000 before the addition of input devices such as the VPL dataglove, costing $9,000. There are also systems being developed which use parallel processors, and exotic platforms well beyond the reach of most schools. Of course there are no standards for this pioneering work, all VR companies being small businesses competing for what is a miniscule market at present - there are but 300 estimated fully immersive systems worldwide (Pimentel and Teixeira, 1993).

As an alternative, the humble PC is capable of being used as a desktop-based non-immersive platform and is thus within the reach of many computer enthusiasts who would like to experience VR first-hand without standing in long queues or visiting Timezone. Software such as Sense8's WorldToolKit and Autodesk's 3D Studio allow the creation of 3D objects and the "flyaround" via special 3D input devices. Although resembling AutoCad architectural walkthrus, the "flyaround" permits the viewer to interact with an object from any angle whatsoever.

Yet another alternative, even more accessible is the use of a software package called REND386 and the Mattel/Nintendo Powerglove and Sega shutter glasses, which can be both attached to the serial port of an ordinary 386 - or

486-based PC. Originally designed by VPL for the Nintendo Entertainment System, the Powerglove, in fact a scaled-down Dataglove, can be used as an input device to control a library of programmed worlds and games. The Sega glasses, also for games machines, permit a 3D effect. It is this platform which could serve the basis for a range of educational ideas which the VR industry is currently struggling to imagine. For while the VR industry is good at producing realistic images and fantastic worlds, there is a dearth of appropriate ideas to best utilise the technology.

Without such personal experience, VR is but pie-in-the-sky for most people. Media hype and the high cost of high-end VR systems mean that the technology will remain mysterious and forbidding by society, that is, until a major manufacturer offers a complete and inexpensive system. But can we as educators sit back and wait for this to occur? VR is already the site of new theory in a whole range of disciplines from Art to Zoology. As educators we need to be able to experience this new technology first-hand, and so be able to make some informed judgements as to its value for our classrooms and for our students. Some of us may be excited by the prospect of new worlds and new ways of teaching. Some of us may even have the skills to develop new VR applications. I believe that we need to start thinking about this technology now, *before* the entertainment industry proffers VR, replete with its own visions, and its own values to our children in the form of the latest arcade game. No other computer application has such a potential for both use and misuse.

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THE DEVELOPMENT OF A PICTORIAL DATABASE TO TEACH PLANT IDENTIFICATION

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The ability to identify specific plant species and have a knowledge of their characteristics is very important for a horticulturist. The teaching of this aspect is a major part of the horticultural courses taught at the Burnley Campus of the Victorian College of Agriculture and Horticulture Ltd. Depending upon the course undertaken students have to learn to identify over 1,000 plant varieties. In addition to species and common names the students must also learn over 20 characteristics relating to growth, special features, tolerances and taxonomy.

The subject has been traditionally taught by the use of collected specimens and plant manuals. This method has been very successful over the 100 years that horticulture has been taught at Burnley but it does have its limitations in the expense of collecting the material and the timing of its availability. Specific identification features such as flowers are obviously only present at certain times of the year.

It was decided that an ideal way to overcome these difficulties, and to assist the traditional approach, was to produce a computerised pictorial data base which contained not only the relevant data pertaining to each plant but also a number of images of that plant as well. These images were to show major plant features for either identification or use.

EXISTING SYSTEMS

A number of plant data bases are available commercially, there are also a number of video disks available which hold plant images, but none combined both data and images. The other problem with the existing systems was that they were not the range of plants that were taught and were common in Australia since some of the systems came from overseas or interstate. The other problem was that the characteristics which were stored in the databases were not those in which we were interested in teaching. It was plainly necessary to develop the database and images ourselves.

WHAT WAS DEVELOPED

The development process took two directions. The first was to utilise the existing images on video disc and to make them more readily accessible to the uninformed user. The video disc play which was used was a Sony LDP3600D. This player will play both PAL and NTSC discs. This was necessary since the discs purchased (Table 1) were from the United States of America and hence were in NTSC format. Normally this player is controlled using a hand control unit in which the user enters the number of the frame they wish to view. To make access easier a controller program was written for a P.C. using the dBase III+ programming language. This was later compiled using Clipper 5.0. Data for each of the 900 plants on the video disk was entered into a data base, this data included Botanical Name, Common Name, and Starting and finishing frame numbers. This meant that images could be accessed via Botanical and Common names or any part there of. Once having selected a plant the user is able to scroll forward and backwards through the images of that plant. In some cases that may be as many as 19 images for one variety.

Name	Images	Video Sequences	Size
Encyclopedia of Landscape Plants	9000	Y	12"
Exotic Plants	2000	Y	12"
Herbaceous Ornamentals	1200	N	8"

Table 1. Video Discs purchased.
All discs were purchased from Videodiscovery Inc., Seattle, Washington.

OUR OWN IMAGES

The second process was to develop our own images and use them in conjunction with the data which was already contained in the plant manuals and stored on disk as Microsoft Word 5.0 files. This data was converted into a dBase III+ file by a conversion program which utilised the standard format of the Word 5.0 plant data sheets. This allowed an easy conversion in much less time than would have been required by retyping the data.

The capturing and use of the plant images was a far more involved exercise. It was decided that since the technology was improving rapidly in this area the images should be captured and stored in as higher resolution as possible, even if at this stage a downgraded image was used to present the data. This was based upon the reasoning that an image would be unlikely to be captured twice, once at low resolution and later after a change in technology again at a higher resolution. The costs of being able to provide multiple displays of high level creation were too great for the project, therefore it was necessary to be able to display the images at lower levels of resolution.

The system for capturing the images comprised:

Apple Macintosh II ci Microcomputer
330Mb H.D., 4Mb RAM, Cannon Erasable Optical Disk
Rasterops 24STV Graphics Card
SVHS Video camera with 35mm slide holder
Mediagrabber 1.0 Software
Photoshop 1.0 Software

The images were taken from 35mm slides and captured using the Mediagrabber software as 24 Bit images which are approximately 1 Mbyte in size. Photoshop was used to convert these images to 16 Bit Targa files which reduces their size to about 320 K.

These files are then transferred to the P.C. system using LapLink Mac III. Once there they are converted the 8 bit Super VGA files of about 156 K. These files are now in a format which can be displayed on a P.C. using a Paradise SVGA card which gives 256 colours x 640 x 480 pixels. There is surprisingly little loss of quality in the image in its reduction from a 24 Bit (16 million colours) to an 8 bit (256 colour) image.

The pathway for capturing the image is set out in figure 1.

The software which is used to link the image to the database is Picture Power 3.1 from Pictureware Inc.
This is a stand alone package that also comes with commands that can be utilised in dBase III+ and Clipper programs. The programs were then written to allow records to be called by Botanical name, Common name and Family name. These were again written in the dBase III+ programming language and complied later using Clipper 5.0 with some minor adjustment.

The software is written to allow the user to see multiple screens of data on the chosen plant and also to call up any images that are attached to the data record (Figures 2 & 3). There is no limit to the number of images that may be attached to each record. The only limitation is the size of the hard disk used to store the package. Currently the system holds data on 1,000 plants and 385 images for 244 of those plants. This requires
63 Mbytes of space on the hard disk. The data is made available to a number of 386 and 486 computers via a network running under Netware Lite 1.0

FUTURE DEVELOPMENTS

The capturing of images and attaching them to the plant database is an on going project. The 35mm slides required need to be of high quality and concentrate on a specific plant. The taking of these slides continues throughout to year as plants show different characteristics at varying times of the year.

The development of other pictorial databases is also continuing. Current projects include a database of Victorian Eucalypt species and also a database of horticultural pest and diseases.

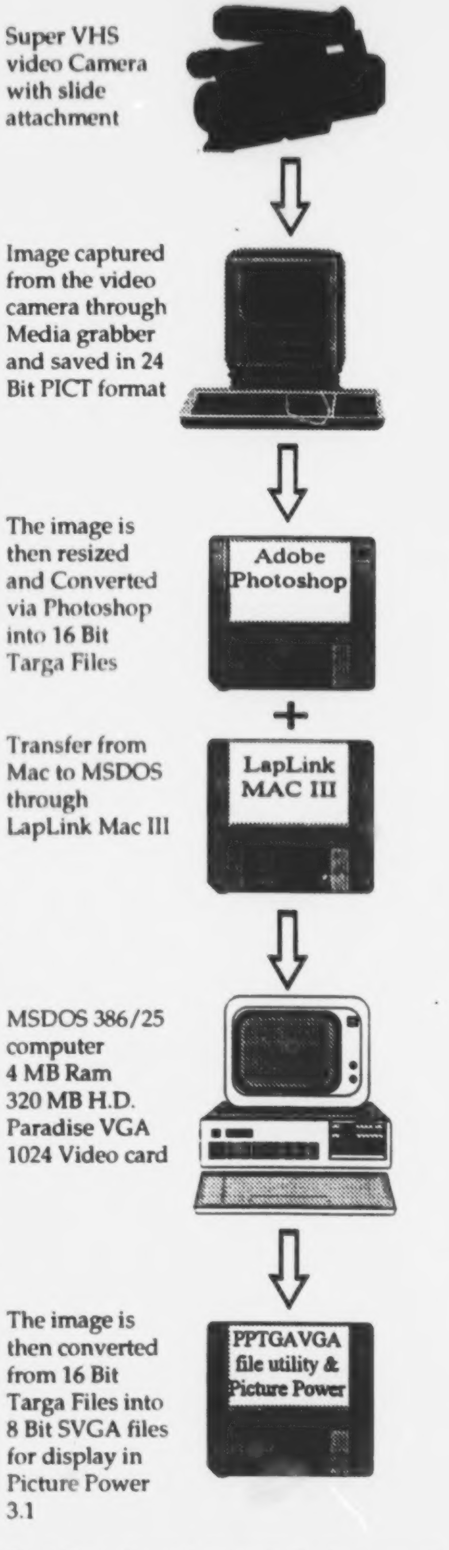
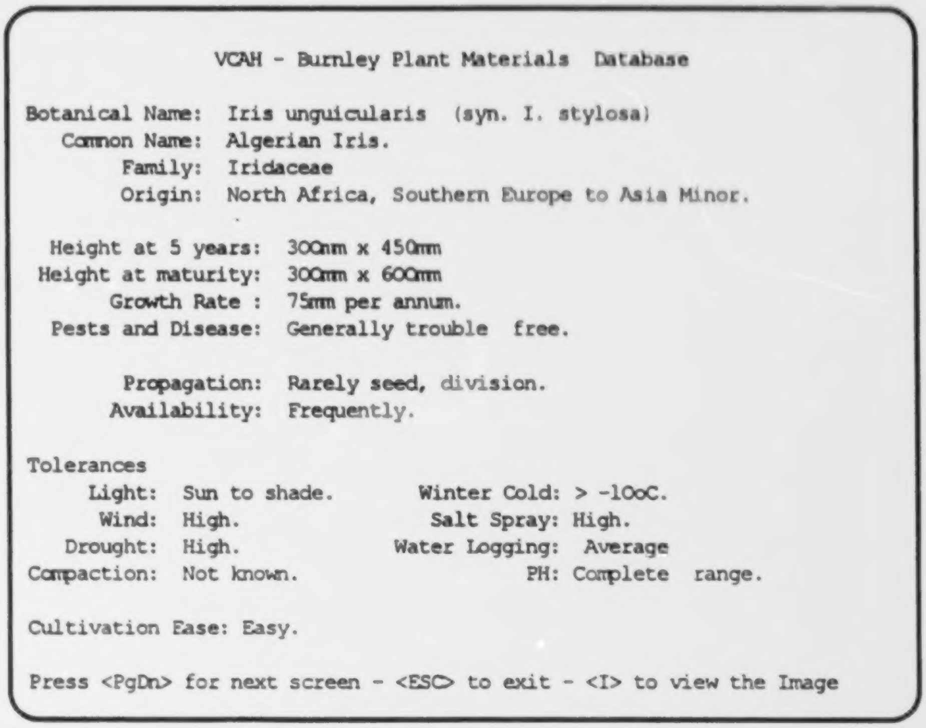
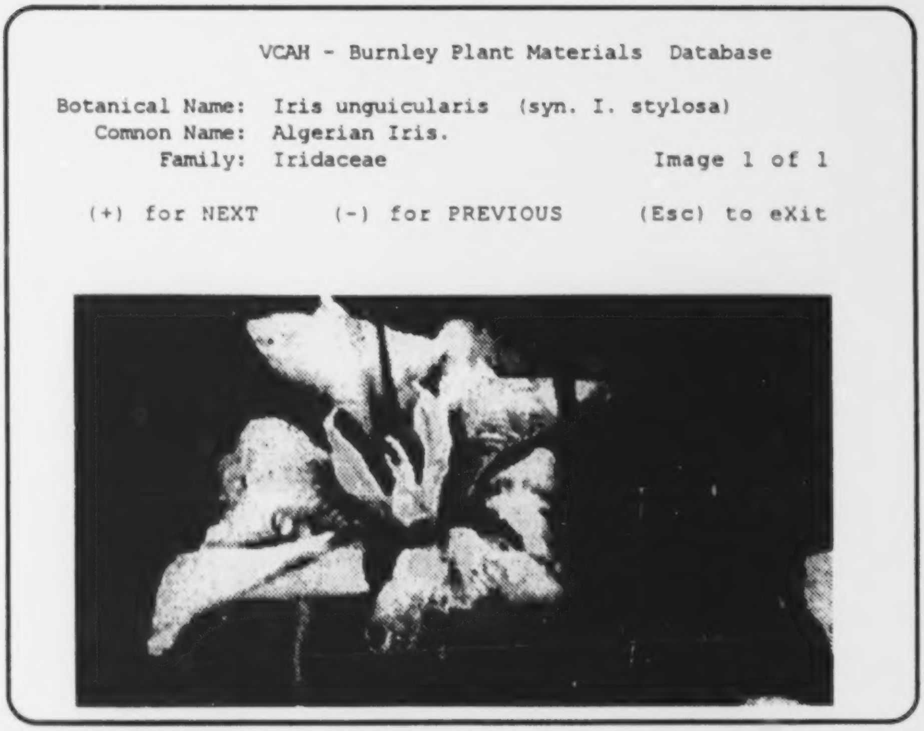

Super VHS video Camera with slide attachment
Image captured from the video camera through Media grabber and saved in 24 Bit PICT format
The image is then resized and Converted via Photoshop into 16 Bit Targa Files
Adobe Photoshop
+
Transfer from Mac to MSDOS through LapLink Mac III
LapLink MAC III
MSDOS 386/25 computer
4 MB Ram
320 MB H.D.
Paradise VGA
1024 Video card
The image is then converted from 16 Bit Targa Files into 8 Bit SVGA files for display in Picture Power 3.1
PPTGAVGA file utility & Picture Power

Fig. 1 The pathway from capturing images on th Macintosh to their display on an MSDOS machi



```
                 VCAH - Burnley Plant Materials  Database

Botanical Name:  Iris unguicularis  (syn. I. stylosa)
   Common Name:  Algerian Iris.
        Family:  Iridaceae
        Origin:  North Africa, Southern Europe to Asia Minor.

  Height at 5 years:  300mm x 450mm
 Height at maturity:  300mm x 600mm
       Growth Rate :  75mm per annum.
  Pests and Disease:  Generally trouble  free.

        Propagation:  Rarely seed, division.
       Availability:  Frequently.

Tolerances
     Light:  Sun to shade.       Winter Cold: > -10oC.
      Wind:  High.                Salt Spray: High.
   Drought:  High.            Water Logging:  Average
Compaction:  Not known.                   PH: Complete  range.

Cultivation Ease: Easy.

Press <PgDn> for next screen - <ESC> to exit - <I> to view the Image
```

Figure 2. Opening data screen of plant database.



```
                 VCAH - Burnley Plant Materials  Database

  Botanical Name:  Iris unguicularis  (syn. I. stylosa)
     Common Name:  Algerian Iris.
          Family:  Iridaceae                 Image 1 of 1

    (+) for NEXT     (-) for PREVIOUS     (Esc) to eXit
```

Figure 3. Plant image screen of plant database.

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A SPREADSHEET SYSTEM FOR EDUCATIONAL USE BASED ON MICROSOFT EXCEL

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The great educational potential of spreadsheet programs such as Microsoft Excel is briefly described and the different types of educational application are outlined. This educational potential is taken advantage of in a system called the Warwick Spreadsheet System which adds additional features to Excel and overcomes a number of drawbacks with using it as it stands. Simple examples are given to illustrate the exploration of data and mathematical modelling using spreadsheets.

Reference is made to the ways in which spreadsheets can aid the learning of concepts particularly in the context of modelling and simulations. This is related to the psychological ideas of concept image and generic organiser. Evidence is given to support a constructivist approach to the use of spreadsheets.

EDUCATIONAL POTENTIAL OF SPREADSHEETS

Spreadsheet programs are now available which combine sophisticated graphics and database capabilities with an easy to use mouse-driven user interface and pull down menus. Such spreadsheet programs offer the following benefits:

- they are *interactive*; i.e. they give *immediate numerical and graphical feedback* to changing data or formulae,
- they enable data, formulae and graphical output to be *available on screen at once*,
- they can solve complex problems and handle large amount of data *without any need for programming*.

Because of these characteristics they have the capability to facilitate a variety of different learning styles which can be characterised by such terms as: *open-ended, problem-oriented, investigative, discovery oriented, active* and *student-centred*. Through such learning styles students having a large measure of *control* and *ownership* over their learning.

Figure one summarises some of the main uses of spreadsheets in educational contexts. These categories are not exclusive but overlap; indeed the boxes in the diagram have been deliberately grouped to suggest areas of overlap. A spreadsheet that calculates the trajectories of projectiles, for example, is an example of a numerical solution being found to a problem; however it could be used as a simulation, it could be a student modelling exercise and it could be seen as a conceptual teaching tool to help the understanding of the Physics involved in projectile motion. However, two main areas of overlap may be distinguished in the diagram: *the graphical exploration and analysis of data* and *mathematical modelling, simulations and solving problems.*

There is not space here to develop in detail the various categories of usage, but discussion of applications in Science and Mathematics will be found in Beare (1991, 1992, 1993a). Further references and examples will be found in Attwood (1992), Beare (1993c), Brosnan (1989, 1990), the CBMACP (1992), Davies (1992), Elliot (1988), Finnemore (1990), Healy and Sutherland (1991), Hewitson (1992), Keeling and Whiteman (1990), NCET (1990) and Osborn (1987).

THE WARWICK SPREADSHEET SYSTEM

In order to realise the full educational potential of spreadsheet and graphical database programs a way of using them is needed which is simple and easy to use in the classroom while at the same

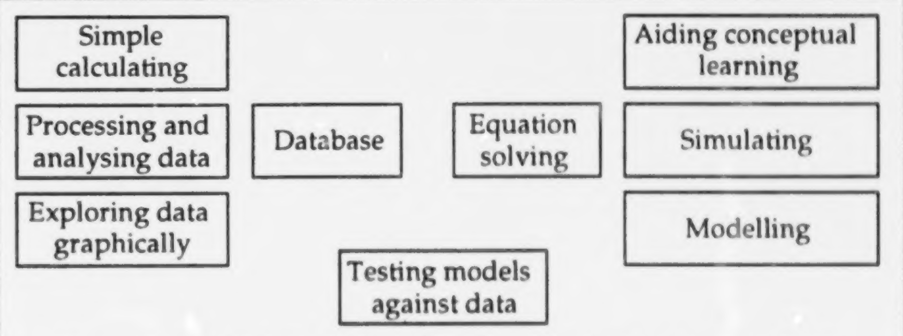

Simple calculating
Aiding conceptual learning
Processing and analysing data
Database
Equation solving
Simulating
Exploring data graphically
Modelling
Testing models against data

Figure One: Different educational applications of spreadsheets

time offering as many educationally useful features as possible. The Warwick Spreadsheet System (WSS) was developed to meet these needs (Beare, 1993b). It is based on Microsoft Excel and has its own set of pull-down menus. The menus contains sets of commands each of which effectively runs a program written to use Excel 's in-built 'macro language' to carry out a particular operation, e.g. plotting a given quantity of a graph or making a fixed copy of a particular plot on a graph so that comparisons can be make with other plots when the spreadsheet data is changed. The system makes use of as many of Excel's educationally powerful features as possible, especially:

- its range of different types of graph and chart,
- dynamic linking of spreadsheet data to graphs and charts so that they change whenever the spreadsheet changes,
- the ability to refer to cells using names, so that formulae can be written in ordinary words or algebraic symbols, (i.e. without needing cell references such as C3 or C3),
- the ability to exchange data with a wide range of other applications including other spreadsheets, word-processors and desk-top publishers,
- *Excel* (and *WSS*) is available for both Apple Macintosh and PC computers.

WSS overcomes a number of problems in using *Excel* . It eliminates:

- much of the complexity of many common *Excel* operations,
- the need for several operations to produce and label a graph or chart, (even with *Excel 4*'s 'chart wizard' facility),
- the bewildering range of different options and possibilities that *Excel* offers, only a few of which are needed in the classroom,
- the need to name cells manually before using names in formulae (*WSS* does this automatically),
- the fact that within *Excel* quantities in successive rows of a step by step calculation cannot easily be referred to without cell references.

During the three and a half year development phase of *WSS* spreadsheets were written for Science subjects and these are published separately, (Beare, 1993c, Hewitson, 1993, Stephen, 1993). These spreadsheets and the *Warwick Spreadsheet System* itself were trialled extensively by Hewitson and Stephen with classes at Oundle School. The resulting feedback was valuable in suggesting what features to include and the best ways of implementing them. Some of these features are:

- up to three charts or graphs automatically linked to each spreadsheet,
- superimposing of separate plots for comparison purposes,
- plotting of all or only part of any set of data,
- easy formatting commands for spreadsheets, charts and graphs,
- best fit lines and exponentials,
- selection of data to meet specific criteria,
- automatic drawing of frequency charts (not done by *Excel* itself),
- easy-to-use modelling system capability.

Some of these features will become more apparent in the next two sections which also show how new spreadsheets are created.

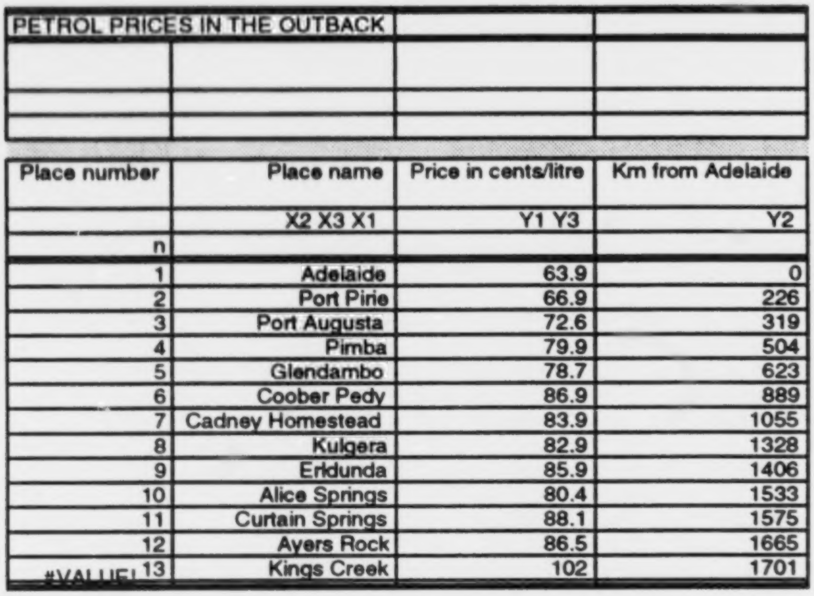
A VERY SIMPLE SPREADSHEET CONTAINING NUMERICAL DATA

Figure 2 shows a spreadsheet set up by a thirteen year old for her Geography homework. It contains petrol prices and kilometre readings logged on a trip through the Outback from Adelaide to the Red Centre of Australia in 1991. Three charts and graphs are shown. WSS automatically saves three Excel 'charts' (some of which might be graphs in the usual sense) whenever it saves a spreadsheet and these are opened automatically when the spreadsheet is opened. The student has used commands such as Choose as y1 to indicate which columns of data are to be plotted. Chart titles and axis labels appear automatically and are linked to appropriate spreadsheet cells. The charts and scatter graph with best fit line illustrate different ways in which data can be explored graphically to find features such as trends and relationships.

The student expected to find petrol prices increasing the farther the fuel had to be transported and this clearly influenced what data she entered onto the spreadsheet and what was plotted. In this way data *interacts* with hypotheses and theories about it, sometimes to suggest what correlations and trends to look for; sometimes to suggest theories after a relationship has been discovered. Why, for example, is petrol so much more expensive at King's Canyon than at Alice Springs?

A SPREADSHEET CONTAINING A SIMPLE MATHEMATICAL MODEL

Figures 3 shows a spreadsheet set up to model hypothetical changes in a population (rabbits perhaps?).



PETROL PRICES IN THE OUTBACK			
Place number	Place name	Price in cents/litre	Km from Adelaide
	X2 X3 X1	Y1 Y3	Y2
n			
1	Adelaide	63.9	0
2	Port Pirie	66.9	226
3	Port Augusta	72.6	319
4	Pimba	79.9	504
5	Glendambo	78.7	623
6	Coober Pedy	86.9	889
7	Cadney Homestead	83.9	1055
8	Kulgera	82.9	1328
9	Erldunda	85.9	1406
10	Alice Springs	80.4	1533
11	Curtain Springs	88.1	1575
12	Ayers Rock	86.5	1665
#VALUE! 13	Kings Creek	102	1701

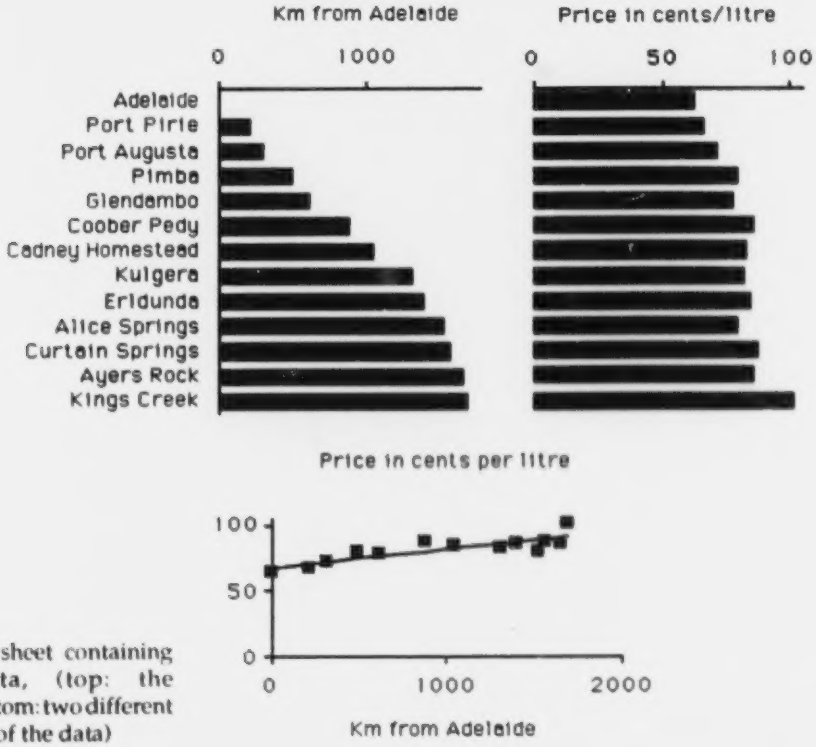
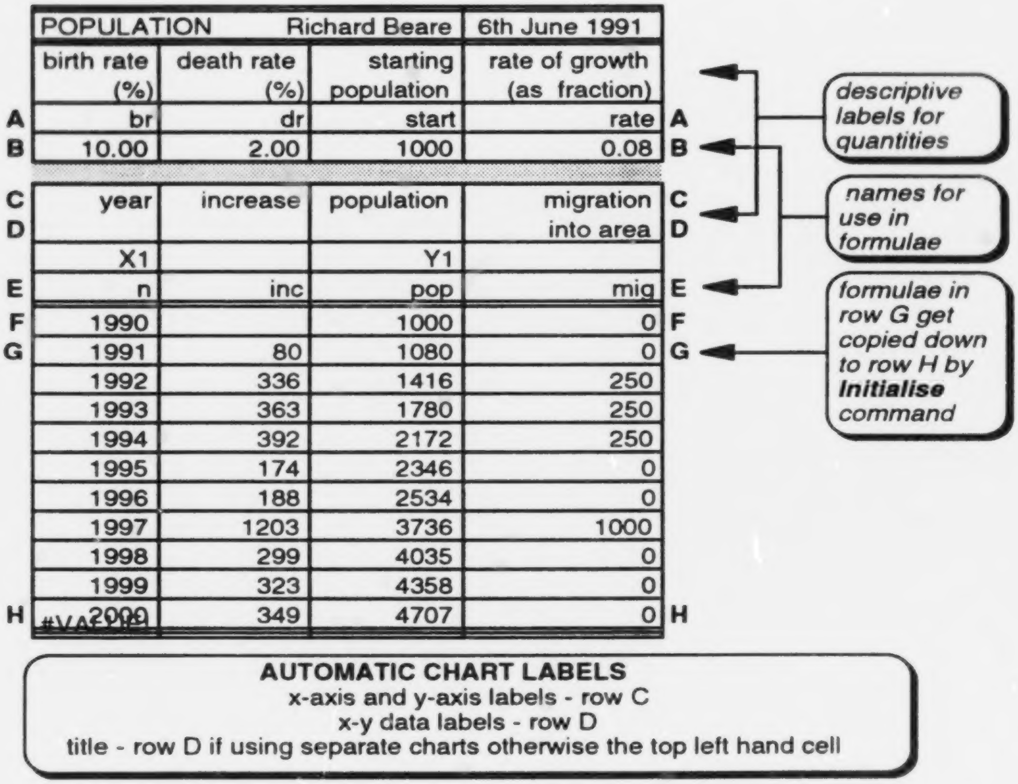


Figure 2:
a simple spreadsheet containing numerical data, (top: the spreadsheet, bottom: two different graphical views of the data)

Figure 4 is the resulting graph. Figure 5 is an alternative way in which the spreadsheet can be viewed. It shows the formulae used.



	POPULATION	Richard Beare		6th June 1991	
	birth rate (%)	death rate (%)	starting population	rate of growth (as fraction)	
A	br	dr	start	rate	A
B	10.00	2.00	1000	0.08	B
C	year	increase	population	migration	C
D				into area	D
	X1		Y1		
E	n	inc	pop	mig	E
F	1990		1000	0	F
G	1991	80	1080	0	G
	1992	336	1416	250	
	1993	363	1780	250	
	1994	392	2172	250	
	1995	174	2346	0	
	1996	188	2534	0	
	1997	1203	3736	1000	
	1998	299	4035	0	
	1999	323	4358	0	
H	2000 #VALUE!	349	4707	0	H

descriptive labels for quantities

names for use in formulae

formulae in row G get copied down to row H by ***Initialise*** *command*

AUTOMATIC CHART LABELS
x-axis and y-axis labels - row C
x-y data labels - row D
title - row D if using separate charts otherwise the top left hand cell

Figure 3: a spreadsheet showing changes in a population

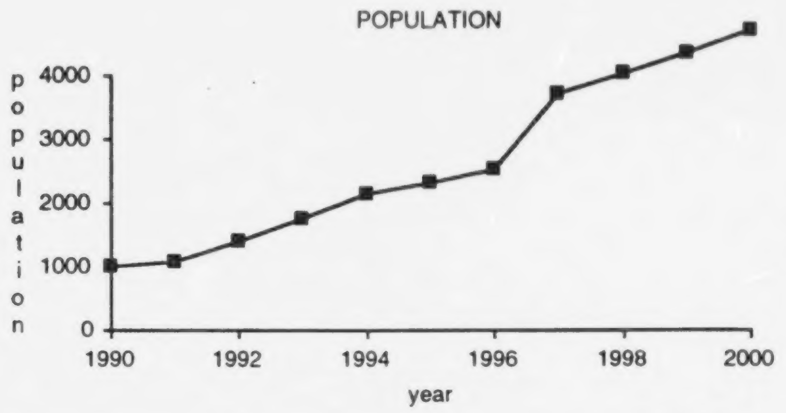
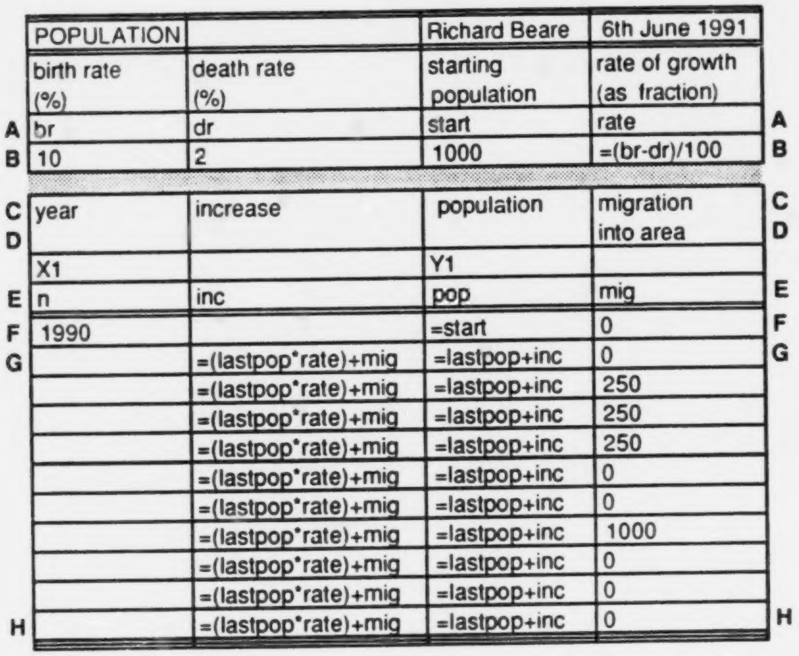
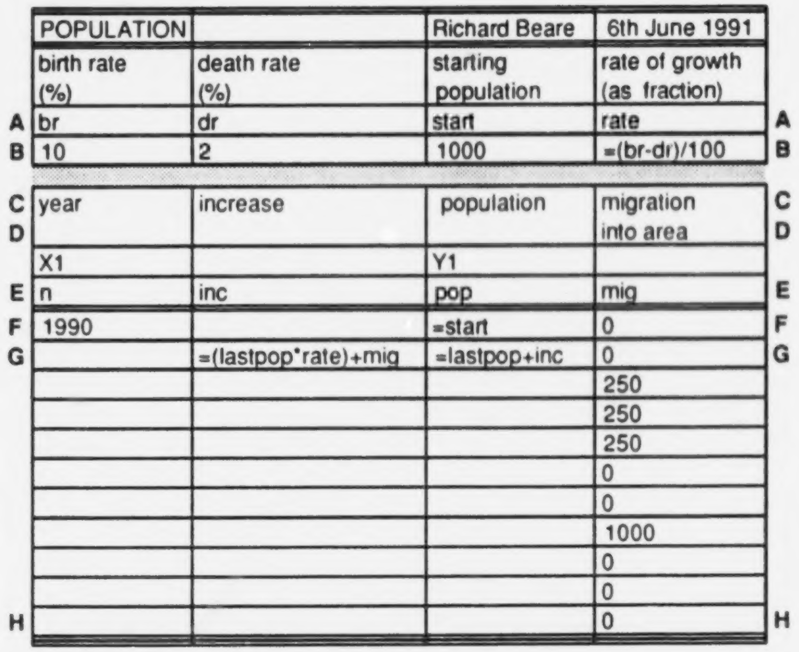


Figure 4: the corresponding graph of population changes



	POPULATION		Richard Beare	6th June 1991	
	birth rate (%)	death rate (%)	starting population	rate of growth (as fraction)	
A	br	dr	start	rate	A
B	10	2	1000	=(br-dr)/100	B
C D	year	increase	population	migration into area	C D
	X1		Y1		
E	n	inc	pop	mig	E
F	1990		=start	0	F
G		=(lastpop*rate)+mig	=lastpop+inc	0	G
		=(lastpop*rate)+mig	=lastpop+inc	250	
		=(lastpop*rate)+mig	=lastpop+inc	250	
		=(lastpop*rate)+mig	=lastpop+inc	250	
		=(lastpop*rate)+mig	=lastpop+inc	0	
		=(lastpop*rate)+mig	=lastpop+inc	0	
		=(lastpop*rate)+mig	=lastpop+inc	1000	
		=(lastpop*rate)+mig	=lastpop+inc	0	
		=(lastpop*rate)+mig	=lastpop+inc	0	
H		=(lastpop*rate)+mig	=lastpop+inc	0	H

Figure 5: an alternative view of the population spreadsheet showing formulae rather than values



	POPULATION		Richard Beare	6th June 1991	
	birth rate (%)	death rate (%)	starting population	rate of growth (as fraction)	
A	br	dr	start	rate	A
B	10	2	1000	=(br-dr)/100	B
C D	year	increase	population	migration into area	C D
	X1		Y1		
E	n	inc	pop	mig	E
F	1990		=start	0	F
G		=(lastpop*rate)+mig	=lastpop+inc	0	G
				250	
				250	
				250	
				0	
				0	
				1000	
				0	
				0	
H				0	H

Figure 6: showing the data and formulae that the user needs to enter (the sytem automatically replicates the formulae in row G)

To create a WSS spreadsheet the numerical data, descriptive labels and formulae required are first entered onto a blank template. (Having such a template necessarily restricts one's freedom a little but it greatly reduces the thinking and planning time for new spreadsheets and makes other's spreadsheets more readily understood.) It will be seen that different sections on the spreadsheet are used for different purposes. The top section (above the shaded area) is used for numerical quantities and formulae that are calculated just once (e.g. the *rate of growth*). The lower section is used for tables of values, both calculated ones, (e.g. *increase* and *population*) and those entered as numerical data, (e.g. *migration into area*). Rows A and E have a key role to play because they contain the *names* that are used to name automatically the quantities immediately underneath so that they can be used in formulae (rows B and F to H respectively). Rows C and D are used to provide (default) titles, axis labels and 'data labels' for graphs and charts. These appear automatically when particular columns are chosen as x and y coordinates.

To set up the spreadsheet one has only to type in the data shown in figure 6. The *Initialise* command then replicates any formulae in the second row of the bottom section (row G) so automatically setting up the series of step by step calculations needed to model the population changes. A useful feature is that constant values (e.g. migration) do *not* get copied down (as they would normally with *Excel*). The top row in the lower section (row F) is not copied down in order that it can be used for initial values and formulae. As can be seen from figure 6, formulae used in a model can contain whole words or just abbreviations and there is no need to employ cell references in formulae (although this is occasionally also convenient). The name *lastpop* refers to the last value of the quantity in the column named *pop*, i.e. the value in the row above.

These features make *WSS* effectively a *modelling system*, but with the important extra feature that mathematical models can be combined with numerical data (as illustrated in simple form by this population spreadsheet). Sometimes this ability to combine formulae and data is very important, for example when processing data from experiments or fieldwork, and when comparing a theoretical model with real data. An example of the latter would be a genetic model that explained how the numbers of dark forms of peppered moths in Nineteenth Century England increased after the Industrial Revolution while the numbers of light forms decreased (Hewitson 1993).

SPREADSHEETS TO AID CONCEPTUAL LEARNING

Fundamental to modern educational thinking is the idea that concepts are most effectively internalised when related to their active use by students in a variety of situations. Such ideas were implicit in Piaget's views on concept development and were behind active approaches to teaching Mathematics and Science. Practical investigations that the pupils carried out were intended to act as vehicles through which students' cognitive structures could develop. Much effort has gone into the idea of mathematical modelling as a means of achieving conceptual understanding through making students express their understanding in quantitative terms (e.g. Gorny, 1988, Schecker, 1991, CBMACP, 1992). A model is just a set of equations chosen by someone (teacher or student) in order to represent an aspect of reality. When, however, it is used by someone to investigate that reality it becomes a simulation. Simulations allow students to explore ideas in a practical way so helping them to develop their cognitive structures . They are less powerful than modelling because the student is only concerned with observable behaviour rather than underlying theoretical relationships. Nevertheless they are very useful because they are accessible to a much wider range of students and need very limited mathematical skills.

Building on the idea of cognitive structures Tall (1989) has suggested the useful idea of software as a *generic organiser*. This is *'an environment (or*

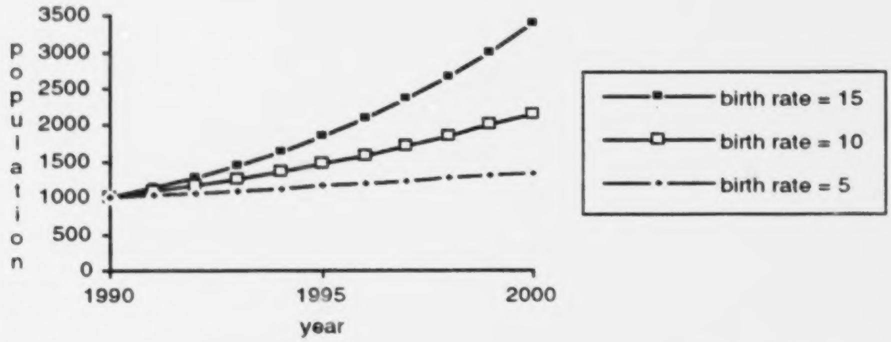


Figure 7: the effect of different birth rates on a population

microworld) which enables the learner to manipulate examples and (if possible) non-examples of a specific mathematical concept or a related system of concepts. The intention is to help the learner gain experiences which will provide a cognitive structure on which the learner may reflect to build the more abstract concepts'. The idea of generic organiser is very helpful in understanding why simulations are useful learning tools. *WSS* provides an ideal environment for the construction of models and their manipulation as simulations. The population spreadsheet described above, for example, could be used to explore the concepts of birth rate and growth rate and how they affect the graph of population growth. This is illustrated in figure 7 where three growth curves have been superimposed for different birth rates, (the death rate having been fixed at 2 per cent per annum and migration having been made zero).

A very great advantage of a spreadsheet system over other ways of modelling and creating simulations (e.g. by programming) is that it is quick and easy to do as the population example demonstrates. The student can therefore more easily understand not just what the computer is doing but how it does it. Tall calls this *specific insight* as opposed to *analogue insight* (where only the principles are understood) and *external insight* where the computer is acting as what a scientist would call a *black box*, i.e. its behaviour is understood but not how it works. The advantage of *specific* insight is that it involves the student in thinking at a deeper level about the ideas involved. It also helps the synthesis in the student's mind between different aspects of a student's understanding of a concept, what Tall calls the *concept image*: *'We shall use the term concept image to describe the total cognitive structure that is associated with the concept, which includes all the mental pictures and associated properties and processes . . . . . As the concept image develops it need not be coherent at all times . . . .'* Given the simplicity with which spreadsheets can be set up using *WSS* one may go even further and suggest that students should whenever possible set them up for themselves - a process which forces them to *construct* their own understanding. This fits in very well with constructivist views of learning and with much work that has been done on *modelling* as an effective learning activity.

CONSTRUCTIVIST WAYS OF USING SPREADSHEET

The author recently used a spreadsheet approach to aid understanding of two different types of biological growth strategy, known as r-selection and K-selection after the significant parameters in the equations governing their growth rates: $dN/dt = rN$ and $dN/dt = rN(K-N)/K$. The first (see figure 8) gives an exponential growth curve and relates (crudely) to species such as greenfly which will rapidly mushroom in numbers when favourable growth conditions exist and then suddenly crash to a low level for a variety of reasons. The second gives a growth curve which is initially exponential but then levels off to the value K. It describes (again crudely) species which are slower growing but more competitive than others in the long run (oak trees for example). The students used a spreadsheet which drew (without their understanding the formulae used) the two types of growth curve. Values of r and K could be altered and different graphs superimposed for comparison purposes.

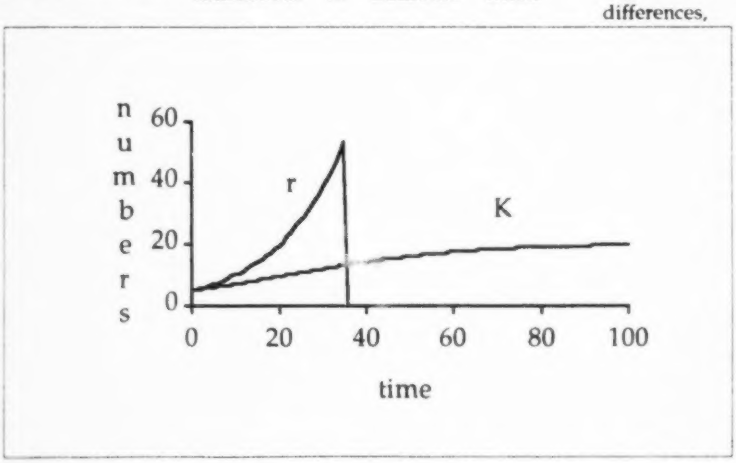


Figure 8: typical growth curves for r and K-selecting species

Three groups of about 20 students each used the same spreadsheet but were given different printed worksheets. At the top of each worksheet a different set of instructions was given as follows:

- 'Prescriptive' group: Go through the numbered instructions and questions in order. Record any answers required in the spaces provided,
- 'Constructivist' group: Before carrying out each investigation I would like you to try and predict the outcome of it and to give reasons for your prediction. Record these things in the spaces provided. Afterwards record your findings. If they differ in any way from your predictions try and modify you explanation to account for the differences,

- 'Open-ended' group: Before carrying out each investigation think about how you are going to carry it out. In some cases the approach might be quite obvious; in other cases it may require some thought. After carrying out the investigation give a short explanation in the spaces provided of *how you went about the investigation and what you expected to find, what you actually found out and what your conclusions were*.

A pre-test and an identical post-test were given as well as an attitude questionnaire. Of those students who originally got a given graphical question wrong, about twice as many subsequently got it right in the 'constructivist' group as in the other two (68% as compared with 30% and 37%). The increases on non-graphical questions (i.e. those testing biological understanding) were about half as great but in the same relative proportions between the three groups. The spreadsheet was intended to help students construct and integrate the various components of a complete concept image of r or K-selection. However it seems that this did not happen efficiently unless specific steps were taken to cause it to happen - as with the *predict with reasons - observe - explain* sequence carried out by the 'constructivist' group. The other groups did not have to *reflect on their own understanding* and many probably noted down what they observed without thinking about its meaning, their motivation being perhaps to *get the right answer* rather than to understand better themselves.

CONCLUSION

Graphical database and spreadsheet programs like Microsoft Excel have a great deal of potential for enhancing learning by performing a range of different functions and facilitating a range of different learning styles. A system such as the Warwick Spreadsheet System harnesses this potential and overcomes many of the difficulties. As Excel becomes more widely available in schools on both Macintosh and PC computers a whole new field of spreadsheet based learning could be opened up. Further development of ready-to-use spreadsheets and further research into the best ways of using them will help develop this new approach to learning.

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MULTIMEDIA AND MONSTROSITIES: REINVENTING COMPUTING IN SCHOOLS AGAIN?

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The selling of computers and their related products to schools, in part, requires that the product is 'reinvented' or constructed for educational purposes and, further, that the categories of schooling (students, teachers, classrooms and curriculum) are, more or less, represented as caricatures of schooling from the 1950's and 60's. By restricting constructions or inventions to new computer products the understandings of the new information and communication technologies in education are normalised and limited.

New, seemingly monstrous constructions such as that of the cyborg, give rise to new, disruptive accounts which provide more useful means of understanding the dilemmas of schooling in an era of increasingly pervasive digital media. The paper describes a particular, new construction in which human and non-human 'actors' are not distinguished. This approach, called the 'actor-network' model, has been usefully applied to the study of a wide range of technical innovations. In this paper it is illustrated by analysis of a recent multimedia release to schools.

THE CURRENT WAVE: MULTIMEDIA

Under the banner of 'CD-ROM to put science in a spin' (McIntosh 1993), The Australian reported a recent launch of an IBM-N.S.W Board of Studies product, a CD-ROM disc for primary school science. This is only one of a number of new multimedia products offered to schools this year. The momentum is clearly growing: multimedia, it seems, is much in vogue for computers in schools. An important part of developing momentum for any new computer related product is to create the same sense of need and urgency that was created in schools when microcomputers first became commercially available and then, for each subsequent set of 'high tech' products. When you look closely at the advertising or press releases or commentary associated with the reporting of new products like multimedia, there is a clear sense of déjà vu. A simple thought experiment in which we swap the multimedia product for, say, an 8-bit microcomputer and step back in time thirteen years would reveal that little has changed in the way that computers and their related technologies are sold–literally and rhetorically–to schools.

Just as in the early 80's and for every previous wave of the new information and communication technologies, schools have little choice. What choice there is is like the choice associated with toothpaste, that is, between brands. For some schools the fact that they have a choice is much less important than that they have to make one. When they first embarked on a high technology path the prospect of never ending purchases of computers and their related products was unimaginable. It has taken some schools a long time to come to grips with this prospect. Others have adjusted to the commercial rhythms of the industry and recyle their computers every year or so and in so doing effectively become an extension of the distribution network of the computer market.

Whether a school resists or adapts to the commercial cycles of the industry, it is useful to ask some questions about the circumstances that most forms of schooling now find themselves in. How is it that in the early 90's consumption of this year's product range is now, more or less, taken for granted? What is it about the technology that makes it "ideally suited" for use in schools? It all seems so natural, so obvious. How do the "educational" properties of things like CD-ROMs arise? How is it that multimedia has become a new and likely significant component of expenditure for many schools?

REINVENTING COMPUTING IN SCHOOLS: OLD CONSTRUCTIONS

We want to argue that the process by which technologies like CD-ROMs, and other multimedia-related products achieve their significance in schooling is, as Grint and Woolgar (Grint and Woolgar 1992: 377) argue, "irredeemably social". Ursula Franklin, in her analysis of the patterns that emerge during the introduction of technologies into society, makes a similar point. She claims that the social acceptance of any technology requires, as a first stage, a period of invention.

> *.. we see that in the early stage of a particular invention, a good deal of enthusiasm and imagination is generated. There are efforts to explore and explain just how wonderful and helpful the new invention will be.... Wellsprings of creativity and freedom from toil seem to be just around the corner. In this phase technologies create human bonds and a sense of excitement in people who feel grateful to be part of such wonderful, progressive times.*
> *(Franklin 1990: 95-96)*

That is, after material development, the physical artefact, the product has, in a sense, to be reinvented socially. If it is to survive in education, it has, over a relatively short period of time, to become an educational necessity. This is what makes multimedia products so interesting at this time. As yet they are not regarded as essential and so it is a good time to observe the processes, the social invention or construction which occurs.

For those who invent particular educational meanings for the new information media, it is important to do so in a way that does not draw attention to the act of invention. Usually the artefact is sufficiently engaging that little effort is required. It is an interesting problem: to be given a particular high technology product and reinvent it, so that it can be sold to as wide a range of schools as possible, with one size having to fit all. It has to be given what appear to be explicit educational attributes, offering either to do something that schools cannot do, or improve in some way something they already do. If an urgency can be created about acquiring the product, all the better.

Reinventing a product with which schools are unfamiliar is a relatively simple task. It typically takes on the guise of familiarising schools with the technology and its educational attributes, tapping what are now deeply ingrained anxieties about a highly uncertain but definitely high technology future. In a real sense, the new information and communication technologies offer a certainty of being a part of a future in which the only thing certain is computers and their associated technologies. It can be expressed in a kind of equation that says:

SCHOOLS + COMPUTERS = LESS UNCERTAINTY

It represents a way of managing the complexity and uncertainty of 'the future'. In such an account it is important to keep the other variable in the equation, schools, as constant as possible. If the new information media are to transform schools to a less uncertain state, then schools need to be seen in a particular and almost constant state of low, or at least lesser, technology. One of the TV advertisements run by Apple last year shows a small girl walking through a dark, bare, old classroom to a Macintosh on a bench. She receives her enlightenment, literally, by turning the computer on. The advertisement would lose much if the girl had to walk past rows and rows of well-lit computers being used enthusiastically by other children.

Extreme caricatures of educational institutions and practices characterise representations of schools and learning by advertising agencies. If we were to accept these representations of schooling, it would seem that since the very earliest days of computing in schools, schools have been caught in a kind of time warp, around about 1950 or 1960, desperately in need of transformation and improvement, a transformation that, as it happens, can be conveniently brought about through consumption of enough of the current product range.

The difficulty is that schools have been acquiring computers now for more than fifteen years. They have changed in part through their use of computers and, as a consequence of being part of a society which has experienced enormous social and economic change, in much of which the new information and communication technologies have been deeply implicated. It would indeed be remarkable if anything had stayed the same over this time.

NEW CONSTRUCTIONS: CYBORGS

So computers and their products require a social invention or construction in order to be sold to society generally and to schools in particular, something that we are witnessing now in the selling of multimedia products. But these are in a sense old constructions: they have been associated with the selling of computers to schools from the days of the first microcomputer and for every subsequent wave of computer-related products. An important part of these constructions is, as has been argued, to hold certain other categories constant while the new one is added. Things like child, student, school and classroom remain the same, so focus remains with the new product. Further, the new product is, typically, gently demonised so that much effort has to be expended in allaying fears about it, running familiarisation courses, awareness courses and so on. Such courses assume an essentially stable, and more or less fixed set of educational givens, i.e. students, classrooms and so on.

A new, gently demonised technology is of course much easier to deal with than however-gently demonised students, classrooms or curriculums. We are therefore uneasy with talk about new kinds of humans, new kinds of classrooms or new kinds of curriculum. Talk about new kinds of humans, post-humans perhaps, is usually relegated to science fiction where new forms humans abound. A significant member of this new class of humans is the cybernetic organism or cyborg. It is a construction[1], literally and metaphorically, that draws attention to the intimate associations we have with the machines of the late 20th century, which as Haraway (1991: 152) suggests:

> *have made thoroughly ambiguous the difference between natural and artificial, mind and body, self-developing and externally designed, and many other distinctions that used to apply to organisms and machines. Our machines are disturbingly lively, and we ourselves frighteningly inert.*

Humans have always had intimate associations with the devices and technologies they have built, but never before with technologies that operate in the manner and at the speed of the new information media. Coupling an organism whose signalling mechanisms operates at about three hundred metres per second with a technology that operates about a million times faster underlines the difference between contemporary machines, computers, and those of the industrial revolution. Previously, humans built devices that were, within an order of magnitude, of similar speed to humans. The speed of these technologies tended to distort geographical scales, but in such a way that people could readily and adequately deal with the distortion by mapping it onto previously known geographies. Now, however, "with the advent of instantaneous communication (satellite, TV, fibre optics, telematics) arrival supplants departure: everything arrives without necessarily having to depart" (Virilio 1987: 19). Instead of distorting the old space-time reality, we live, as Virilio argues, in speed-space, a space in which the speed of the new information technologies distorts "the illusory order of normal perception" (Virilio 1991: 100). Speed blurs the boundaries between human and machine, boundaries that once were regarded as fixed. In an age of an increasing range of prosthetic machines, just what is us and what is machine is increasingly unclear. Katherine Hayles puts it this way:

> *If corneal implants are part of us, why not contact lenses? If contacts, why not eyeglasses? If eyeglasses, why not an automated telescope? If a telescope, why not the computer interfaced with it? Gibson, in an interview (Greenland 1986), pointed out that a teenager playing an arcade video game could be considered a cybernetic unit. ... By this reasoning anyone who finds a word processor indispensable for writing is already in a cybernetic circuit. The only distinction between it and the cyborgs in Neuromancer [his SF novel] is how difficult it is to detach the various parts from the circuit.*
> *(Hayles 1990: 217)*

These are disturbing images. They are the things we prefer to ignore. These considerations surely don't apply to computer-using educators? After all, we have found ways to negotiate this new technological culture, or technoculture (Penley and Ross 1991). Some of us grew up at a time when there was no video or television, and computers were arcane devices used by men in white coats, or so film representations told us. Our ways of seeing the world were developed at a time when the pervasiveness of digital media was almost unimaginable. We are more or less certain that our use of computers hasn't changed us (much?), but can we be as certain about the students we teach?

> *[W]hen we read about young people ('kids') attentively watching two films projected side-by-side on a screen and the adults in the audience getting up and walking out (Adams 1991); when we are told by teenagers that 'you don't understand MTV, you process it'2; when we watch three- and four-year-olds use the remote controls of VCR's to replay a favourite section of a cartoon over and over; when we see five-year-olds almost merged with the control pad of their Nintendo game; and when we see extremely young children explore a Macintosh drawing program in ways we never believed possible, our perceptions are constrained and filtered: we cling to reassuring categories and recollections of an age when the world seemed more predictable, less fragmented, and certainly more immediately tangible. To explain (away) what we 'see', we resort to causal accounts that draw upon experiences from a period in which digital media were far less intrusive.*
> *(Green and Bigum 1993)*

Dator (1989) makes the point more bluntly,

> *Since we live within the envelope of the dying (or marginalizing) print cultures and the rise of audio-visual ones, those of us who have been conditioned all our lives 'to think like a book' usually ignore, disparage, or simply cannot understand those who may learn to think and to express their thoughts through moving holographic images. Being so (literally) brainwashed by print, we can no more truly understand the new cultures that are overwhelming us than we can truly understand 'the savage mind' of pre-literate societies we distorted or destroyed.*
> *(Dator 1989: 363)*

These are scandalous, dangerous, even monstrous images. They are not the images that vendors would like associated with their multimedia products. It is in the vendors' interests to keep categories simple, obvious, uncomplicated. Yet old categories that artificially separate human and machine arguably restrict our ways of thinking and speaking about the new information and communication technologies. In equivalent automobile terms, we limit ourselves to thinking about "horseless carriages".

The same patterns of category appear on a larger scale when talking about the social and the technical. When talking about technical artefacts we position the social as context, or when speaking of the social, the technical is context.

delineation of a scenario. It speaks for others but in its own language" (Callon 1986a: 26). How successful translation is depends upon how well the actor-world redefines those actors or elements which are likely to challenge their redefinition.

Translation then, is the general term that is applied to the methods that an actor uses to "enrol" other actors in a network. One such method is "problematisation", a form of translation that posits the indispensability of one actor's 'solutions' for another actor's 'problems' (conveniently defined by the first actor). In the case of the CD-ROM disc, IBM's chief designer for the project is reported as saying: "For teachers, this product will be a valuable curriculum tool in a subject area regarded by many teachers as traditionally difficult to teach". The problem, the teaching of primary science is defined as difficult and traditionally so. Primary teachers of science are being persuaded that 'their' problems in teaching science can be 'solved' with this disc. The curriculum designer with the N.S.W. board of Studies is quoted as saying: "Our aim is to introduce young students gradually to a number of sophisticated concepts without intimidating them". The 'problem' is further defined in terms of student fear of "sophisticated concepts", something, presumably teachers have trouble teaching. As Callon says: ".. to translate is to speak for, to be indispensable, and to displace. All translation works to solidify actor-worlds. Successful translation quickly makes us forget its history" (Callon 1986a: 28).

In the final part of translation, actors have to be "displaced" in the construction of a network. It is insufficient to simply use words, to describe new roles for the various actors of the actor-world; redefinition only occurs through action. "Interessement is the group of actions by which an entity ... attempts to impose and stabilize the identity of the other actors it defines through its problematization" (Callon 1986b: 208-209). For example, in the example being considered, the links that currently exist between science teachers and their students will have to be disrupted. The use of the term "tool" imagines a particular kind of disassociation, one with which most teachers who use computers will be familiar.

So, in order to enrol teachers in an actor-network that contains a CD-ROM disc, Make the Connection!, the IBM Ultimedia machine, the N.S.W. Board of Studies and IBM Australia, at least, it is essential for the "heterogeneous engineer", in this case IBM Australia, to be able to speak on behalf of science teachers and have other actors in the network act in predictable and supportive ways. To do this, IBM has to treat each actor as a kind of "black box", ignoring the complexity that each represents. Each actor masks a set of other actors which it draws together. The N.S.W. Board of Studies is more complex than the single entity described in this example. Science teachers may well prove to be difficult to "black box". Even CD-ROM technology may not be as stable a black box[3] as IBM requires.

The simplification of entities is a necessary part of linking them in an actor network. Without simplification it would not be possible to do the redefinitions of role that IBM has embarked on in this example. Some of the black boxes would appear, at first sight, to be somewhat more stable than others in the network. We might, for instance, imagine that the predictability of the Ultimedia machine is much greater than that of N.S.W. primary teachers. Simplification is also the basis of the power of any network. Each actor, which can be represented as a network of actors, each of which in turn can be represented by networks of actors, and so on in a kind of hierarchy or fractal arrangement, derives its strength and credibility from the mass of silent actors beneath.

The construction of this actor network thus depends upon the resistance of the various actors that make up the actor-world. Is it easier to change primary teachers, science curriculum, the N.S.W. Board of Studies, primary students, or the educational characteristics of CD-ROM discs? One aspect of the history of this actor-network that would be most interesting to record is the translation of the Board of Studies from an organisation presumably concerned with the planning, design and evaluation of school curriculum to an organisation which is a vendor, and even an exporter, of CD-ROM discs. The other interesting translation is of I.B.M. Australia, essentially a hardware and software vendor and manufacturer, into a 'high tech' curriculum designer and developer[4]. Other translations (e.g. of primary teachers) have yet to occur.

All translations, or at least those that are effective and lead to stable configurations of actors, need to be "anchored ... to physical and social displacements" (Callon 1986a: 27). The actor-world if it is to survive has to build up materials that make it "durable". So presentations at Computer Education conferences, reports in the computer sections of newspapers, trials, evaluations and experiments will all contribute to making the network last. Of course, the key stage in the history of this actor-network will be the enrolment of science teachers. The disc will need to be more than an optional extra if investments are to be recouped. It will be therefore interesting to see what methods are employed to "translate" the primary teachers of N.S.W. into the 'technosystem' that is now forming in Australian education, as elsewhere in advanced capitalist societies.

STORY TELLING

The story of the current reinvention of computing in schools can be told many ways. There is not the space available to describe the (reassuring?) stories derived from technological determinism (the existence of the disc will coerce teachers into using it), social determinism (adoption or rejection of the disc will be a matter of social construction by teachers), or accounts of "designer technology" (Grint 1992: 153-4) (the "political qualities" [Winner 1985] of the disc will determine its acceptance, use etc.). Accounts like these

This never allows us to consider simultaneously the social and the technical. In work that is concerned with explaining the development and stabilization in societies of different technologies, Law, Latour, Callon and their associates have developed an approach in which they regard the social as never purely social but, rather, as technosocial, being comprised of networks of human and non-humans. It is to their work that we now turn.

ACTORS, NETWORKS AND MULTIMEDIA

The organising premise of what is referred to as 'the actor network model' of Callon (1986a,b), Law (1988) and Latour (1988) is that no distinction is made between humans and non-humans. Replacing both categories is a single category or "heterogeneous" entity called actor. Actors together can then constitute a network, the whole assemblage being referred to as an actor-world. A network then "is composed of a series of heterogeneous elements, animate and inanimate, that have been linked to one another for a certain period of time" (Callon 1987) :93. The model is best illustrated by example and we have chosen a small one from the current work concerned with the educational reinvention of multimedia products for schools. The data from which this analysis is based is taken from a press report which, although limited, offers enough information to illustrate the workings of the model.

The newspaper article (McIntosh 1993) reports the launch of a CD-ROM disc for primary school science. The disc is the first of a series of discs being jointly produced by IBM Australia and the NSW Board of studies.

First, IBM, the prime mover in this account, defines a certain scenario for the teaching of primary science in schools. Science is described as being "traditionally difficult to teach". Teachers are described as welcoming of "a valuable curriculum tool" for this area. The disc offers a "high level of interactivity" to students, as opposed to, one presumes, a low level of interactivity for students in "traditional" science classrooms. As the account develops, an actor-world Callon (1986a: 22) emerges, a world made up of a number of entities (the N.S.W. Board of Studies, the Ultimedia machine, the CD-ROM disc, the lenses, the laser, the grating, the photodiode, primary teachers, primary students, etc.), each with their repertoires and histories redefined by IBM. None of these elements can be placed in a hierarchy or categorised usefully. The laser is as important as the science teacher. If we took out any one element, the whole would collapse. The interdependence of the elements is described by Callon:

> *Accordingly, technical objects must be seen as a result of the shaping of many associated and heterogeneous elements. They will be as durable as these associations, neither more nor less. Therefore, we cannot describe technical objects without describing the actor-worlds that shape them in all their diversity and scope.*
> *(Callon 1986a: 23)*

The actor-world is the place where a set of heterogeneous entities have their roles, how they are related, their identity, and even their history redefined for them. The process of redefinition is termed "translation". In the example under consideration, IBM attributes to the N.S.W. Board of Studies an identity, a role to play, a course of action, and projects to conduct. IBM attributes properties to CD-ROM discs, the way they work, how they are to be used, and so on. The translator becomes the spokesperson for each element that is redefined:"Translation is a definition of roles, a distribution of roles and the delineation of a scenario. It speaks for others but in its own language" (Callon 1986a: 26).

How successful translation is depends upon how well the actor-world redefines those actors or elements which are likely to challenge their redefinition.

Translation then, is the general term that is applied to the methods that an actor uses to "enrol" other actors in a network. One such method is "problematisation", a form of translation that posits the indispensability of one actor's 'solutions' for another actor's 'problems' (conveniently defined by the first actor). In the case of the CD-ROM disc, IBM's chief designer for the project is reported as saying: "For teachers, this product will be a valuable curriculum tool in a subject area regarded by many teachers as traditionally difficult to teach". The problem, the teaching of primary science is defined as difficult and traditionally so. Primary teachers of science are being persuaded that 'their' problems in teaching science can be 'solved' with this disc. The curriculum designer with the N.S.W. board of Studies is quoted as saying: "Our aim is to introduce young students gradually to a number of sophisticated concepts without intimidating them". The 'problem' is further defined in terms of student fear of "sophisticated concepts", something, presumably teachers have trouble teaching. As Callon says:

> *".. to translate is to speak for, to be indispensable, and to displace. All translation works to solidify actor-worlds. Successful translation quickly makes us forget its history" (Callon 1986a: 28).*

In the final part of translation, actors have to be "displaced" in the construction of a network. It is insufficient to simply use words, to describe new roles for the various actors of the actor-world; redefinition only occurs through action. "Interessement is the group of actions by which an entity ... attempts to impose and stabilize the identity of the other actors it defines through its problematization" (Callon 1986b: 208-209). For example, in the example being considered, the links that currently exist between science teachers and their students will have to be disrupted. The use of the term "tool" imagines a particular kind of disassociation, one with which most teachers who use computers will be familiar.

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On the other hand, stories that call up monstrous images, of the part-machine, part-human cyborg, or of networks of actors in which no distinction is made between the non-human and the humans, are, to say the least, disturbing. They disrupt the dreams (of reason?) about this and each new wave of information media that is sold to schools. Most importantly, at this time of high interest in multimedia, they disrupt normalising accounts of media and education, and draw attention to the growing range of new and emergent relationships between media (multi or otherwise) and education.

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FOOTNOTES

1 A construction that already enjoys considerable scholarly discussion and writing to the point that properties and attributes are debated seriously. For instance, Terry Harpold (1993) recently suggested that "a good measure for the cyborg [is] someone who doesn't worry that the digital sign will fade".

2 David Smith, Faculty of Education, University of Sydney, personal communication, July 1991.

3 This can be read in terms of the technical reliability of current technology as well as the possible shift in CD-ROM technology to a different assemblage of actors.

4 Another instance of the shift from Education per se to the media as the institution determining curriculum, schooling etc., see (Hinkson 1991).

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EMPLOYING CONSULTANTS TO RETRAIN BUSINESS STUDIES TEACHERS

BY GREG CALVERT
Principal Curriculum Officer Work Related Studie, Department of Education and the Arts, Tasmania

The Computers for Commercial Subjects program was designed to replace the ageing and irrelevant typing equipment in Tasmanian state schools with state-of-the-art hardware and software that will provide students with the opportunity to use the same equipment that services the needs of business and industry.

The program was initiated in the light of a study conducted in 1986: Facilities for Commercial Subjects in Tasmanian Secondary Schools and Colleges. (unpublished).

At that time, keyboard, typing and word processing skills were taught in Business Studies courses, conducted in rooms mainly equipped with manual typewriters, some schools had a small number of electric and electronic typewriters. Arising from this report was the recognition that micro-computers could be used to introduce students to a range of skills which were being requested by a number of employers, including many in small businesses. Amongst these requests was the need for students to be skilled in the use of spreadsheets and data base management.

Initial pilot work began in 1988 at Ogilvie High School. The program itself began in 1990 and the original plan was to complete it in 1993. This schedule coincided with the introduction of the new Tasmanian Certificate of Education at Year 9, substantial changes in syllabuses having occurred to reflect the use of micro-computers in business.

All 68 secondary schools were to benefit from the program. The majority of these schools were to receive $36,000 towards the provision of microcomputers. District high schools, being smaller, were to receive a pro rata allocation.

Because of a reduction in the planned amount in 1991/2, the program has been extended to achieve its objectives.

IMPLEMENTATION

Tasmanian schools have used the program for four major purposes:

1. Acquisition of hardware, particularly IBM-compatible and Macintosh microcomputers.
2. Acquisition of software, particularly Microsoft Works in high schools and Word for Windows, Word 5 and Excel in the senior secondary colleges.
3. Provision of training. The sophistication of the hardware and software being purchased and the lack of previous computing experience on the part of many of the teachers involved highlighted a need for training.
4. Upgrading of the furniture and fittings in rooms that are being used for commercial subjects so that they are ergonomically suitable, and reflect modern offices.

The funding principle is that central funds provide approximately 60 percent of the cost of replacing the typewriters and refurbishing the keyboarding rooms, with the school responsible for the remaining 40 percent.

The first use of school funds was to provide furniture, electric wiring and data cabling for printing. Any further funds were put into additional computers, software and other support equipment.

In 1989-90 all schools were advised to select IBM compatible unless they had compelling reasons to justify another selection.

In 1990-91 the equipment selection was increased with the addition of the Macintosh Classic range. At the same time the BBC Master Compact and the IBM compatible XT (except for the laptop version) were deleted.
teachers indicates that the provision of training services from a consultancy outside the Department can be delivered with a very high degree of success.

The overall equipment selection by schools for 1990-91 was as follows:

Type of computer	Number	Percent
IBM Compatible	218	63.2
Macintosh	101	29.3
Archimedes	26	7.5
Total	345	100.0

This selection reflected the program recommendation on choice of computers with the overwhelming choice, 92.5 percent, being the machines which are used in the workplace.

SOFTWARE

As the intention of the program was to make business studies and keyboarding courses relevant to the needs of business, it was necessary to use industry standard software or software capable of teaching industry standard concepts. As a result, there has been a focus on character, paragraph formatting, styles, mail merge, introductory spreadsheet concepts, and the use of storing names and addresses in a database.

Microsoft Works for DOS or Windows, and Microsoft Works for the Macintosh have been widely used in Year 9 and 10. At college level Word for Windows, Word for the Macintosh and Excel have been used.

TEACHER TRAINING AND SUPPORT

It is recognised that training is an essential part of any re-equipment program. As a result of the limited amount of systemic support which was available from within the Department of Education and the Arts, central funding was made available to provide seminar leaders from an outside consultancy firm. The seminars were organised on a district basis for all secondary schools. They are free-of-charge to all teachers of commercial Subjects but schools are responsible for travel and teacher relief.

Separate seminars were held for IBM compatible and Macintosh computers, ranging from introductory sessions on the equipment, their operating systems and MS Works through to advanced teaching applications.

Training and support currently takes four forms:

1. SEMINARS

The majority of these aim to develop teachers' application skills. Other seminars are school based and address curriculum specific issues, for example, the use of spreadsheets for Accounting students.

2.IN-SCHOOL SUPPORT

The consultants work with a particular school to assist it to more efficiently use its laboratory or software. This assistance was especially important in setting up a network or resolving printing problems.

3.ONGOING TELEPHONE SUPPORT

This service involved trouble shooting, giving advice about equipment purchases, follow up to seminars especially relating to application use or curriculum related matters.

A telephone hotline service was provided on specified days after the release of a booklet listing the State Purchasing and Sales Contract providers and giving details of recommended equipment..

4.NEWSLETTER

A newsletter has been provided for the first time in 1993. This has been developed to improve communication about the program to teachers. It incorporates a seminar list with registration form, reviews of software and tips relating to the use of applications.

THE USE OF A CONSULTANCY SERVICE TO UNDERTAKE TRAINING

The program is managed by a Principal Curriculum Officer in the Curriculum Services Branch, Department of Education and the Arts. The PCO is involved in developing policy direction, is the contact point for teachers about training needs, and is responsible for managing the tendering process for the provision of training services and for the monitoring of the program.

One very distinctive aspect of the project has been the use of a computer consultancy service to undertake the training and support aspects of the project. This in part coincides with the downsizing of the Department of Education and the Arts (Tasmania) which reduced its ability to continue to service the needs of schools and colleges through the Elizabeth Computer Centre (now known as the Information Technology Branch). The latter now is concerned with computer management systems rather than educational computing issues.

A tender has been advertised annually for each of the past three years. In each year the tender has been successfully won by The Quill Consultancy in Hobart. Tenders have had to address specific criteria in the tender documentation submitted;

1. Demonstrated ability to provide courses which are relevant to the needs of teachers of Commercial Subjects. In particular there is a requirement that the courses be designed to meet the specific curriculum needs of schools.
2. Demonstrated expertise in both the use of, and training in, specified software packages.
3. Expertise of those involved in the training.

4. Willingness to run courses in all parts of the state.
5. Quality of training materials.
6. Demonstrated ability to provide teachers of commercial subjects with information about the implementation of the concepts they acquire in the training courses.
7. General expertise in the area of computer applications.
8. The availability of backup resources.

An examination of feedback forms from teachers indicates that the provision of training services from a consultancy outside the Department can be delivered with a very high degree of success.

EVALUATION OF SEMINARS

Tables I to V indicate that the consultants in 1991 and 1992 scored in excess of 90% in providing information for an appropriate knowledge level. In combining ratings 5 and 4 for effectiveness, respondents also scored the consultants in excess of 90% for their presentation of the seminars, quality of materials and relevance of the topics to the

TABLE I

PRESENTATION OF INFORMATION FOR KNOWLEDGE LEVEL

RATING	1991	1992
Appropiate	91%	90%
Too Elementary	6%	10%
Too Advanced	1.5%	
No Response	1.5%	

TABLE II

COVERAGE OF TOPICS

RATING	1991	1992
5 (Effective)	43%	60%
4	43%	33%
3	6%	7%
2	3%	-
1(Ineffective)	2%	-
No Response	3%	-

TABLE III

PRESENTATION

RATING	1991	1992
5 (Effective)	61%	68%
4	29%	23%
3	4%	8%
2	-	-
1(Ineffective)	-	-
No Response	6%	1%

TABLE IV

MATERIALS DISTRIBUTED AT SEMINARTS

RATING	1991	1992
5 (Very Useful)	75%	68%
4	22%	25%
3	-	5%
2	-	-
1(Not Very Useful)	-	-
No Response	-	2%

TABLE V

RELEVANCE OF TOPICS TO THE CURRICULUM

RATING	1991	1992
5 (Very Relevant)	72%	63%
4	18%	33%
3	4%	2%
2	2%	-
1(Not Very Relevant)	-	-
No Response	4%	2%

curriculum. There was an improvement in the coverage of topics from 1991 to 1992 so that now the combined rating of 5 and 4 for effectiveness exceeded 90% of respondents.

CONCLUSION

The use of an outside consultancy to assist in the training of teachers is possibly unique amongst Australian Education Departments. Dr Grahame Dowling in a recent paper1 has indicated the increased use of professional consultancies in a wide variety of fields. Usually such services are used to rectify management mistakes rather than in an ongoing role. The most important choice criterion (ie. reputation of the consultants in the specific functional area) indicated by Dr Dowling in his paper is also reflected in the selection criteria for this program.

The employment of outside consultants to undertake training has proved to be cost effective and an efficient delivery mechanism in relation to this project. As an illustration of this, the current March-April 1993 training program of 12 seminars was planned in December 1992. The consultants with 6 trainers (each of whom has developed specialist knowledge) were able to respond to 4 seminars being conducted in one week towards the start of the school year (an optimum period to capitalise on the previous November-December training program). The Department through this type of organisation avoids on-costs and course development costs.

Importantly, the use of consultants in this program signals a new field of possible future employment of consultancies as providers of a range of training activities. However, it should be recognised that the successful use of consultants, in this program, can be directly attributed to an implementation and training strategy which recognises that the provision of computing hardware and software itself will not ensure change in schools.

Dowling, G. (1993) Buying Professional Services - A Client's Perspective. Management No 1. Jan/Feb. p 13-14

OPEN DISCOURSE TOWARDS ENRICHED COMPUTING HIGHER EDUCATION: BACKGROUND FOR AN INTERPRETIVE ACTION-RESEARCH CASE STUDIES

BY MARK CAMPBELL-WILLIAMS

Lecturer, Information Systems, Business Faculty, Edith Cowan University, Western Australia

There is growing evidence that computing education as generally practiced tends to propagate a narrow technicist mindset, a type of instrumental rationality that springs from a positivist liberal ideology. This can create a 'poor' teaching/learning environment - an example of what C. A. Bowers (1992) refers to as "moral poverty of the information age". Other, perhaps richer values and worldviews are rarely given opportunity to influence computing education.

This paper is an initial report on an interpretive action-research study being conducted in computing higher education at the School of Management Information Systems, Business Faculty, Edith Cowan University.

Lecturers, tutors and students are being encouraged to disclose their values, goals and worldview beliefs (relevant to information systems). This is based on an application of Yurgen Habermas' theory of communicative action(1984, 1987) which stresses open discourse. The research questions are: to what extent can values, beliefs and goals be disclosed in information systems studies and does this disclosure enrich the teaching/learning process?

INTRODUCTION

For more than fifteen years in Australia and overseas I have been involved in industry, then secondary, then TAFE, then computing consultancy and now university computing education. My work in education has been immeasurably enriched by the advent of microcomputers and I have seen many students, especially the handicapped and those who do not score well in tests, enabled to achieve sometimes remarkable results and to display uncharacteristic enthusiasm about education through using this technology.

However, I am disturbed by an underlying, almost universal aspect of current computing education. I perceive that lurking behind the user-friendly interface may be a hegemonic process of indoctrination. Computing education as generally practiced may indoctrinate students into a narrow technicist mindset, into an instrumental rationality that would view the natural and social world as consisting of objects to be dominated and controlled through technology for the desires and interests of autonomous human concerns. To coin a phrase from Bowers (1992), it can be argued that this situation is morally poor, perhaps even morally poverty stricken.

Even with the 'explosion' of multi-media and the widespread use of powerful educational hardware and competent educational software across the curriculum, I would still tend to agree with Weizenbaum that:

"The computer is a powerful new metaphor for helping us to understand many aspects of the world, but ... it enslaves the mind that has no other metaphors and few other resources to call on." (quoted in Fleit,1987).

And possibly even more controversial (the emphasis must be on "the fundamental questions in education"):

Computers drain resources, and what is worse, they make people think problems are being solved when they are not. I don't think computers will be any better for answering the fundamental questions in education than were television or audiovisual equipment. (1977, p.76). [my emphasis]

I would say that one of these "fundamental questions" in computing education is whether education is an indoctrination into a dominant ideology or whether education allows for the understanding and exploration of the dominant and other ideologies. The crucial point is that every person and community has a dominant ideology (springing from a dominant worldview with associated values) that is reflected in the education process. Bowers presents a compelling case in his book The Cultural Dimensions of Educational Computing: Understanding the Non-Neutrality of Educational Computing (1987) that education computing is not value neutral but endorses and indoctrinates into a dominant ideology - in our education system this ideology is associated with a whole host of 'isms' such as technicism, positivism, rationalism, naturalism, materialism, scientism, and liberalism. This ideology, for which I will use the term technicism (because of our focus on information technology), tends to "view all aspects of human experience in terms of problems that require technical solutions" (Bowers, 1988, p.8).

In his recent article Ideology, Educational Computing, and the Moral Poverty of the Information Age (1992) Bowers relates his earlier work to the ecological crisis:

> I have already argued that the epistemology embedded in computers, in spite of the technology's capacities to collect and process vast amounts of data relating to changes in the earth's ecosystems, contributes to deepening the ecological crisis. Thus I want to focus here more specifically on how the educational uses of computers reinforce the nihilistic tendencies in liberalism - which must also be understood as having devastating consequences for the rest of the biotic community. (1992, p.20).

Bowers is addressing a second "fundamental question" in computing education - the extent to which computers divorce students from the reality of their natural and social environments. He contrasts technicism (expressed in what he sees as the moral poverty of computing education) with other worldviews that understand humans as interdependent members of a larger biotic community. He ends the article with a passionate plea that "the real crisis is not the lack of data or computer literacy, but in the lack of a form of moral and spiritual development that takes account of the interconnectedness of life." (1992, p.21)

For instance, in a computer simulation of cleaning an oil spill, students are not only vicariously divorced from experiencing reality but they are left with the impression that in a similar way, using information technology, scientists and engineers can deal with real ecological disasters. Here there is a vicarious knowing without really knowing or experiencing; of being twice divorced from reality; of solving chimerical problems while the technology gives the impression of being able to cope with the real problem.

I have used some terms which may be unusual to computer educationalists. 'Worldview' is generally understood to be "a set of presuppositions (or assumptions) which we hold (consciously or unconsciously) about the basic makeup of our world" (Sire, 1976, p.17). The term 'lifeworld' will be discussed as synonomous with worldviews in communal situations. I will use the term 'ideology' to allude to economic or political overtones which, although important, will not be explored in this paper. Thus, the technicist worldview of a society may be referred to as a technicist ideology in relation to, for example, educational indoctrination. The term 'rationality' (as in 'instrumental rationality' or 'communicative rationality') is used as to refer to a person's or a community's way of thinking and acting which results in a habitual 'mind-set'. Thus the technicist worldview may be seen to outwork itself in a technicist mind-set, an instrumental rationality. For example, in my information systems lectures I find it difficult (surrounded by a technicist worldview) not to give the impression that our 'information age' is superior and more generally advanced than other 'ages' - the text books and the videos are usually peons of praise for technological progress. I find it difficult to express the idea that the information age is seen by many philosophers to be morally and spiritually inferior (Macintyre, 1985). Surrounded by an instrumentally rational millieu, I find it difficult to legitimately express the idea that the only way instrumental rationality can think of solving ecological problems is by technological control and domination of people or things - that there are other ways of thinking that promise more hope.

WIDER THEORETICAL BACKGROUND

Since the 1930's, critical theory has contended, from a moral position led by social philosophers such as Horkheimer, Marcuse, Heidegger and Adorno, that the values associated with instrumental rationality (including technicism) have increasingly and destructively dominated business, industry, government and education in modernity (Agger, 1991; Held, 1980). Referring to the current environmental predicament, Dryzek (1990), from an ecological perspective, states that, for persons under the grip of instrumental rationality the human mind and its desires are absolute and all important - the natural world and other people are viewed as mere objects for manipulation, to be dominated. With this fundamental intention to dominate, he contends that there develops an overly goal-oriented approach, a tunnel vision which is blinding to alternative approaches, an individualistic, competitive manner of forcing results at whatever cost to the surrounding natural and cultural and social ecology. Instrumental rationality abstracts persons from the world and from others, blocks them from truly experiencing life to the extent to which it is adopted. In business for example, the best way of returning a profit is thus viewed as individuals "making a killing" rather than the communal and ecological perspective of sustainable viability in the long term with profit sharing and worker participation.

The leading thinker in contemporary critical theory, Jurgen Habermas (1929-) provides a fruitful theoretical position. A unity of perspective has characterised all Habermas' work, basically how to understand modernity, in particular the capitalist modernisation of society, but also a distinction between 'work' and 'interaction' and a close, reciprocal collaboration between philosophy and the social sciences. Habermas refers to his recent work as fallible and open to change - a platform for research rather than a static philosophy of reality (White, 1988, p14). Since around the 1970's some of the distinctive core themes have been communicative action or communicative rationality (White, 1988, p. 1), and social evolution in terms of social systems as distinct from the lifeworld (that is, viewed on one hand from a position "outside" of the community; and on the other hand, from a sociological and psychological perspective from "inside") (Dews, 1986, p. 14).

Communicative action will be taken to refer to any human discourse oriented to achieving exchange of ideas, negotiation, consensus, understanding or problem solving. I will use the term 'open discourse' to refer to that discourse which addresses values, goals or worldview beliefs. Such discourse can be initially encouraged by detailed introductions and simple name remembering games at the first meeting. Similar activities can be used to allow the teachers and students to progressively disclose their personal values, goals and worldview beliefs with relevance to the discipline being studied.

As exemplified by A Theory of Communicative Action (1984, 1987), Habermas argues that communicative action can balance instrumental rationality (White, 1988). I am exploring this possibility. Can educational discourse in the lecture theatre and computing laboratory be used to balance technicism? Can students and teachers alike explore and question the dominant positivistic technicist values by discussing values, goals and understanding of information technology that spring from other worldview beliefs? Does this open discourse lead to an enriched teaching/learning process?

Habermas asserts that humans have a "lifeworld", "an implicit knowledge that can not be represented in an infinite number of propositions; it is a holistically structured knowledge, the basic elements of which intrinsically define one another; and it is a knowledge that does not stand at our disposition, inasmuch as we can not make it conscious and place it in doubt as we please." (Habermas, 1984, p. 34). Furthermore:

> Subjects acting communicatively always come to an understanding in the horizon of a lifeworld. Their lifeworld is formed from more or less diffuse, always problematic, background convictions. This lifeworld background serves as a source of situation definitions that are presupposed by participants as unproblematic. (p. 70)

I take this lifeworld to be pre-theoretical understandings and beliefs and thus can be taken as synonomous with worldviews in communal situations. I am exploring the extent to which worldview based values and beliefs can be explored through open discourse. Can values and beliefs associated with the dominant technicist ideology be disclosed and compared with other values and beliefs from other worldviews?

Habermas is also concerned by what he terms the "colonisation" of lifeworlds - "like colonial masters coming into a tribal society" - when instrumental rationality forces itself into lifeworld understandings via the 'steering' media of bureaucracy or institutional funding. In computing education I am interested to see if the dominant ideology of positivistic technicism does indeed colonise the lifeworlds of teaching/learning groups through the steering medium of computing education.

INSIGHTS FROM CONSTRUCTIVISM

The context to be explored is that of computing education in which recent works (Bowers, 1988; Young, 1989) have shown a more mature understanding of Habermas' communicative theory compared with earlier interpretations such as Grundy (1987). There has been insightful work to relate technicism back to personally held individual world-views and belief systems which can be disputed in educational discourse (Sires, 1976, 1988). Somewhat similar understandings are incorporated in a recent development in educational theory known as 'radical constructivism' or 'social constructionism' (Tobin, 1991; Taylor and Fraser, 1991; Taylor, 1990) and in feminist pedagogy (Davis, Steiger and Tennenhouse, 1989). Tobin's understandings of negotiation in the learning process sound akin to Habermas's communicative action:

> The heart of the curriculum is negotiation of meaning. ... The process involves discussion and attentive listening, making sense of the points of views of others, and comparing personal meanings to those embedded within the theories of peers. ... Justifying one position over another and selecting those theories that are viable can lead to consensuses that are understood by those within a peer group." (1991, p. 32)

Habermasian understandings of lifeworld, ideology and critical consciousness and reflection are used by Taylor (1991):

> It is important that teachers become critically aware of the nature of the prevailing ideology that shapes their pedagogical beliefs and practices, and of their social roles in propagating the ideology amongst colleagues and students. A critical focus on the metaphors, images and myths embedded in the discourse between teachers and students is likely to reveal the sociocultural underpinnings of established teaching and learning practices .... From the perspective of critical curriculum theory, an alternative vision would focus on the development of both teachers and students as autonomous intellectuals who are capable of both criti-

> cal reflection and socially responsible action in relation to the democratisation of their lifeworlds. (p. 20)

Viewing computer tutorials as scenes for teaching/learning cultures complete with images, metaphors and myths has been a fertile tool. In the following quote from Tobin (1991), 'tutor' or 'lecturer' could be read for 'teacher' and 'computer lab' or 'lecture theatre' for 'classroom':

> Myths are usually negotiated within the culture and are accepted by those who belong to the culture .... The teacher as controller of students is a myth that pervades classrooms. Although it does not seem appropriate for students to be emancipated in every sense, there is a strong rationale for teachers to emphasize emancipatory interests with respect to learning. From a constructivist perspective students must have control over their own learning. Referring thoughts and actions to the myth of teacher as controller of students has led to the highly controlled learning environments that characterize traditional classrooms. Changing the myth might lead to interesting changes in classroom environments. (p. 33)

It is interesting to think that perhaps tutors could see themselves as 'social directors' for learning rather than as 'individual student helpers' and as 'learning facilitators' rather than as 'expert knowledge givers' or as 'movie directors with a script and actors' rather than as 'business consultants'. The metaphors suggest certain Habermasian understandings of cognitive interests and ideas of communicative action and, indeed, may give glimpses into lifeworlds.

The following edited extract (names changed) from a recorded interview (17 August 1992) with one of the tutors from the pilot research may serve as an example of the rich ideas generated by this approach:

MARK: "When I was talking to her before, Peta said that she considered that the metaphor or image she saw herself to be as a computing tutor was that of an aeroplane instructor. She extended that to see herself as a parent bird teaching another bird to fly or something like that. A flying instructor at one time will pass on the skills to the student and then the student takes off as it were, and in the process of taking off they learn skills themselves as they go along. First we help getting them over the hump and then they start soaring, being powered, as a metaphor. I thought about that a bit and it's a good metaphor in some ways for empowerment but it's an unfortunate metaphor because it's just one to one, it's just the individual students themselves. There is no idea of the community, of a tribe, of a group, being empowered."

JANE: "I see myself as more as a football coach. A lot of people coming in with a lot of different skills and so they're working towards a common goal, which is to win. But they all have different jobs to do and they all have different skills."

MARK: "And you're the team working together."

JANE: "I do, but I see it as a coaching role that you have to understand that as a coach that they are all very different and they are all in there for different purposes."

MARK: "Perhaps then an analogy you might be able to think about yourself as coaching an athletic squad."

OPEN DISCOURSE

In my experience it is rare for values and worldviews other than positivist technicism to be given a hearing (let alone weighty consideration) in conferences, especially in information systems. Even though every major tenant of positivism has been shown as problematic (Macintyre, 1985), most academics still talk and write and give conference papers based on this position. Given the dominance of positivism with its belief that science and technology are value free (note the glaring inconsistency) it is very difficult to credibly state other values, goals, and worldview beliefs in computing conferences.

However, in the lecture theatre, the tutorial, the laboratory, or the classroom there are many opportunities to gently allow disclosure of teacher and student values and beliefs with relevance to the intellectual discipline of information systems. Strategies included an interactive lecturing approach and encouraging tutors and students to engage in rich discourse in tutorials through the use of detailed introductions, the writing of learning journals (which the tutors have to check regularly), group work, work partners ('buddies') and the encouraging of some form of disclosure of ideologies to do with information systems. The following quote from a unit outline describes the learning journal format:

> "The student general learning journals may include some or all of the following headings:
>
> a. A significant personal learning experience - a powerful learning highlight (what you learnt, and how you learnt it) that was personally relevant to either your life and/or work. This would not usually be a formal or conceptual insight but rather an existential experience to do with your personal journey of discovery in this area. You should also include insights or experiences made during the week either at work or at home. We would be especially interested in any insight you may have regarding the way in which this unit may be part of your overall intellectual and moral development and also in comments on the affective area (feelings or emotions).
>
> b. Reflective examination of your own performance and contributions in lectures and tutorials, and your participation in the unit. A record of your comments or questions made in lectures or tutorials should be noted as should, perhaps more importantly, any relevant informal discussions or interactions either with the learning group or outside. You could also comment on your perceptions of the personal and communal group dynamics in the tutorials (e.g. who is doing what and why; if and how the learning group is helpful to the learning process, formal and informal leaders, co-operation, etc.)

c. Every second week you should include newspaper and journal article clippings that have contributed to your learning experience.

In an introduction to the journal you should list your beginning competency level and previous experience (approx. one page) and your expectations for the course (approx. one page). A reflective summary (approx. one page) and an account of your own values and goals with relevance to information technology (approx. one page) should conclude the journal."

The learning journal is a way of for students to clarify their values, goals and beliefs relevant to information systems. J. Sires (1976) classifies nine major world-views (in Western societies) as rationalism (ie technicism, scientism, positivism), existentialism, nihilism, rationalist deism, existential deism, mainline Christianity, eastern mysticism, 'new age' and, problematically, an ecologically oriented 'Gaia' world-view. This classification can be helpful for description and classification but it is rather threatening to disclose values or worldviews explicitly, as indicated by the following student learning journal comments from the first pilot study 1992:

"One only comment not favourable of the unit, was the subjective content - that is emotions etc. Learning journals are a good way of getting feedback, however, I could not see the point of expressing emotions, feeling this subject is one of science and objective & logic, unless used purely for graphical self indulgence."

In the second pilot study in 1992 I found it less threatening for students to firstly clarify and discuss goals and strategies to use information systems. Then it was easy to discuss the underlying values and worldview foundations. The actual process can begin with extensive introductions at the first tutorial to allow interaction and communicative action to build a community of trust and mutual respect. The following journal entries demonstrate this process:

"I have not been previously exposed to the Learning/General Journal assignment process to be used in this unit. I must confess that the experience of describing one's feelings and emotions, or of providing information about how a university unit may contribute to your overall moral and/or spiritual development, is new and something of a surprise." (student journal, Dec.1992)

"Initially, I felt somewhat odd about the comments on the moral bankruptcy of information technology, however some of your later question sheets helped to put things in perspective. Although I must confess that I had difficulty understanding some of those philosophical questions, I can see now that there are two sides to the issue and that information technology can have both positive and negative effects. (student journal, Jan.1993)"

DISCUSSION

Prior to the pilot research interventions, the tutorials were conducted in the usual manner - on an individualised, one person per computer basis with the students working keystroke by keystroke from a detailed technical work book. The tutors occasionally gave whole-group assistance technical techniques, but usually provided individual assistance where necessary. There was minimal discussion and group interaction. Students were usually assessed on a practical test, a wordprocessed academically referenced essay or a software integration assignment, and an end of semester theory examination (all competitive, stressful and not open to negotiation either in assessment weightings or methods). The highly structured workbook seemed to impose a rigid technicist agenda on the tutorials. Students were given no opportunity for reflection or discussion, being forced by the schedule to cover the maximum amount of the material in the shortest possible time without interuption.

All the elements of technicism seemed to be present: a goal-oriented and task-oriented method to 'cover' the material; a competitive, individualised approach; a lack of team or group work; a lack of discourse - even the lack of superficial discussion or whole group question and answer; a lack of time for reflection on the deeper meaning or purpose or socio-eco-cultural impact of computing; a lack of a group identity to the tutorials; an absence of humour, or art or games or other human aspirations or relaxations; and an overly serious and stressful attitude towards the teaching/learning situation. The tutors seemed to find that the workbook simplified their roles in the tutorials and they thought that the tutorials were proceeding successfully. Students were usually apprehensive about more general educational tasks, commenting on early attempts to incorporate group activities that these were "wasting time" and "being distracted" from the technical aspects of the course.

The process of rigorously interpreting results will take a long time as the research continues. However, early results do tend to suggest that significant inroads can be made in enriching the teaching/learning process in computing higher education by using open discourse. Initial subjective feedback from students is tentatively encouraging as the following representative comments may suggest:

STUDENT 1: I have found this unit far more enjoyable, than other units I have completed. The whole unit was a learning experience, well presented & a pleasure.

STUDENT 2: I have found this unit extremely interesting, and enjoyable. To the extent that I have decided to take Information Systems as a major. The lectures and tutorials have been informative & entertaining.

STUDENT 3: [Semester 1 was prior to the research interventions]

The School of Management Information Systems at Edith Cowan University now uses the learning journals as a significant pedagogical approach in its major core unit on all 3 campuses and in other units in post-graduate and office automation studies. There is significant interest and enthusiasm, as well as significant hesitation, demonstrated by lecturers, tutors and students alike.

Semester 1 (only did 6 weeks)

- boring
- better
- very parrot form straight from the book
- Non approachable lesturer and tutors
- students just did their work not really interacting with one another

Semester 2

- better
- videos and props used in class is of in terest
- lecturer and tutor very approachable and keen to "help you along the way"
- more class interaction was good (the buddy system worked quite well)

It would be fair to say that the research interventions have had significant impact in many teaching/learning situations and have created some considerable ferment as people discuss and examine personal, communal and societal values, worldviews and ideologies in computing education. This in itself is an indicator that a moral poverty is being addressed and teaching/learning is thus being enriched.

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STUDENTS, TEACHERS AND ELECTRONIC MAIL

A VOYAGE OF DISCOVERY INTO A NEW WAVE OF EDUCATIONAL ISSUES

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This paper describes the impact of an initiative which has brought electronic mail to the classroom in terms of research and development activities which have grown from the original endeavor. The research and developement activities described include: a process of interactive and participatory design has been followed to develop an easy to use set of menus and commands to access the system; some practical guidelines on the use of electronic mail with primary and secondary school students has been developed; a peer-support structure for teachers involved with electronic mail has been set up; and software designed to help an understanding of how students use electronic mail and computer conferencing has been written.

"Quick! Look! I've got a letter from America", shouts Nicky Cook, a year 4 student at Glendal Primary School. Excitedly, her classmates gather around her computer. This no ordinary letter. It wasn't sent through the mail, but rather arrived electronically via an electronic mail system (Hall, 1993).

This is just one of many stories of excitement that an electronic mail system, which was reported on at the 1992 Australian Computing in Education Conference, can bring to a student. This is an inexpensive system that makes it potentially possible for every computer in a school to be available as a communications tool, in the same way as they might be word-processing or database tools (Chandler, Gesthuizen and Clement, 1992).

The innovation, which works on a stand-alone computer or in a local area network environment, allows students and teachers to use a local-only FidoNet bulletin board (referred to as a mail point) to communicate with other students and teachers all over the world by electronic mail and computer conferences.

By posting a message into a conference, it will be distributed to many hundreds of similar computer systems around the world for others to read. This means that your letter or reply has the potential to be read by thousands of people who regularly browse their mail. In this way, inter-school and inter-cultural communication can be established, which may develop into more formalized co-ooperative projects (eg. telesesations, and cohen et al).

In times to come, each computer in a school will have full internet connectivity (Carlitz, 1992). In reality, there are a multiplicity of resourcing issues at the local, regional and national levels which need to be addressed before this becomes a reality. It is sufficient to note that such connectivity is not just around the corner. We see the mail point concept as a cost-effective way of bringing something of that ubiquitous access to the classroom. Thus, having largely broken through the barrier of access, we are able to look into what might be the next layer of issues for students, individual teachers and schools as a whole.

A number of research and development activities have grown around the use of mail points, which have come about in response to this "next layer of issues". A number of these are discussed below.

ESTABLISHING A SCHOOL BASED MAIL POINT

In modern bulletin board systems (such as the Ezycom package), almost every aspect of the function of the system can be customised to the taste of the system operator. System operators often put a lot of time and energy to make their systems interesting, entertaining and functional.

For someone who wants to establish a functional mail system quickly, this is not an appropriate approach. It is daunting for a new system operator or teacher to design and write their own screens and menus. We set out to design a set of default or common menus and screens that could be used by other similar educational mail point systems in Victoria.

To help those who may want to establish a mail point, an easy-install utility was also developed.

MENU STRUCTURE AND INTERFACE DESIGN

One anonymous observer has noted that, "in contrast to many on-line systems, bulletin boards are people-orientated services which set the standard for the interface".

The challenge facing many bulletin board operators is how to provide a structure that can be effectively navigated by an intending group of users and yet provide access to hundreds of different conferences.

Our group of users covered a range of primary and secondary school students aged from 7 to 16 years old. We have endeavoured to practice interactive and participatory design at all stages (Schneiderman, 1987, 390-394).

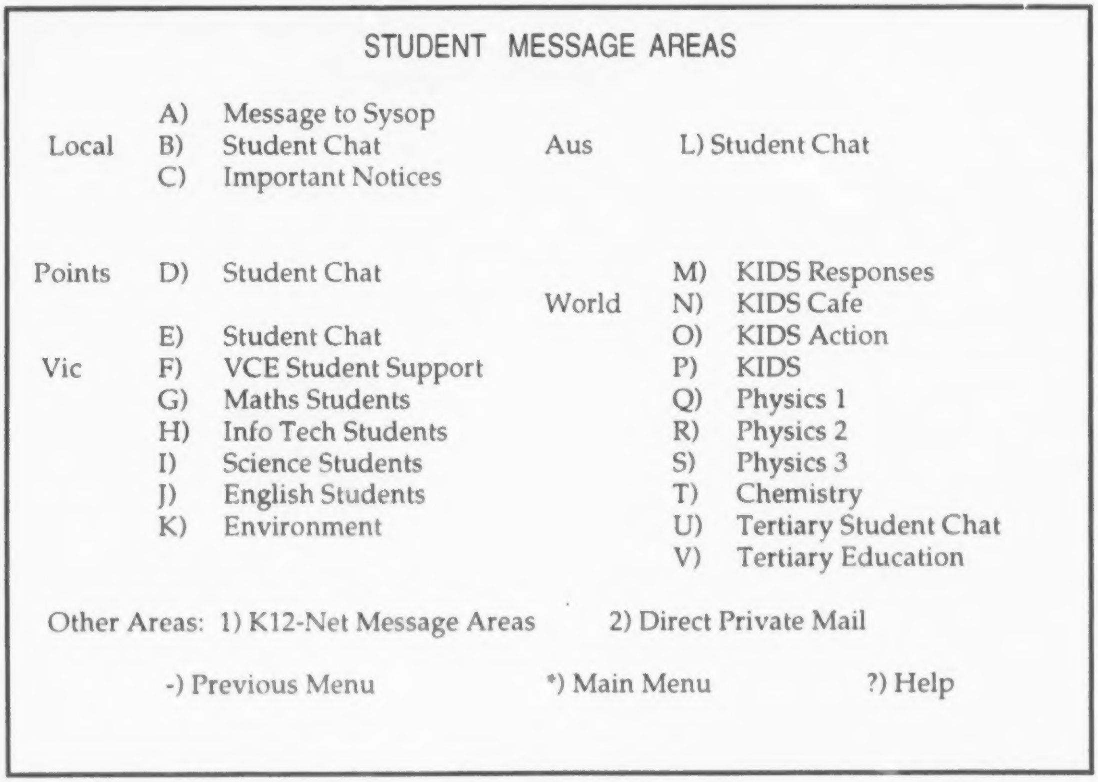
We needed to blend our knowledge of technical feasibility with the aesthetic sense of what will be attractive to students and teachers who will use the mail point. By using a combination of computer-managed user questionnaires, feedback from the students by talking with them and watching them use the mail point, we gained valuable understanding and information about task performance and usage by all users.

So far we do not we feel that this process of development and change is finished, although students are proud of their contribution. Time spent analysing user needs before launching into a large scale project is indeed time well spent. The problems we encountered are not uncommon amongst other online services. Insights we have gained might give others guidance how they can set up a school based electronic mail system.

MENU STRUCTURE

As noted above, the number of international conferences would not all fit into one menu, so they needed to be grouped according to a scheme which the students would find easy to use.

For example, all K12Net conferences were grouped together then they were grouped again into their discussion types of "chat", "subjects" and "projects". Further grouping according to "breadth of audience" (eg. local, national or international conferences) helped the users have some idea of those who would be reading their contribution in any particular conference (Figure 1).



STUDENT MESSAGE AREAS

Local
A) Message to Sysop
B) Student Chat
C) Important Notices

Aus
L) Student Chat

Points
D) Student Chat

Vic
E) Student Chat
F) VCE Student Support
G) Maths Students
H) Info Tech Students
I) Science Students
J) English Students
K) Environment

World
M) KIDS Responses
N) KIDS Cafe
O) KIDS Action
P) KIDS
Q) Physics 1
R) Physics 2
S) Physics 3
T) Chemistry
U) Tertiary Student Chat
V) Tertiary Education

Other Areas: 1) K12-Net Message Areas 2) Direct Private Mail

-) Previous Menu *) Main Menu ?) Help

Students do not need to be aware of teacher-only conferences, nor do teachers need to be aware of student-only conferences. We used a feature in the bulletin board software that allowed us to display menus appropriate to the user depending on the his or her security level.

The menu structure resembled a tree type structure with many levels (Figure 2).

```
 Main Menu
  _—— Message Areas
  _ _—— Local Message Areas
  _ _ _—— Messages to the Sysop
  _ _ _—— Local Student Chat
  _ _ _—— Local Teacher Chat
  _ _—— Regional Message Areas
  _ _ _—— Regional Student Chat
  _ _ _—— Regional Teacher Chat
  _ _—— Australian Message Areas
  _ _ _—— Australian Student Chat
  _ _ _—— Australian Education
  _ _——International Message Areas
  _ _ _—— K12-Net Message Areas
  _ _ _ _—— K12 News &
                Information
  _ _ _ _—— K12 Chat Message
                Areas
  _ _ _ _ _—— (another level)
  _ _ _ _—— K12 Language Message
                Area
  _ _ _ _ _—— (another level)
  _ _ _ _—— K12 Subject Message
                Areas
  _ _ _ _ _—— (another level)
  _ _ _ _—— K12 Project Message
                Areas
  _ _ _   _—— (another level)
  _ _ _—— Other Message Areas
  _ _   _—— (another level)
  _ _—— Fidonet Netmail
```

Figure 2 : Original Menu Structure

As more educational conferences were added to the mail point, the menu structure grew even bigger, and it was noticeable that users were having problems finding conferences that were of interest to them and that they were getting lost in a maze of menus. As the interative design process proceeded, a new set of menus was developed to address these concerns. In later designs, we have attempted to allow as many conferences as possible to be displayed on the one menu, and then placing boxes around each grouping of conferences. The new menu structure is now much smaller and both students and teachers find it easier to browse through to find a desired conference. (Figure 3)

```
 Main Menu
  _—— Student Message Areas
  _ _—— Direct Private Mail
  _ _—— K12-Net message Areas
  _   _—— K12-Net Project &
              Channels
  _—— Teacher Message Areas
  _ _—— Direct Private Mail
  _ _—— K12-Net message Areas
  _   _—— K12-Net Project &
              Channels
  _—— Other Message Areas
  _ _—— K12-Net Message Areas
  _ _ _—— K12-Net Project &
              Channels
  _ _—— Direct Private Mail
```

Figure 3 : Current Menu Structure

AWARENESS OF AUDIENCE

We wanted to be quite helpful in guiding students to use appropriate conferences. For instance, it is inappropriate to mix subjects and, say, discuss health education in a physics conference, or initiate general chat in a subject-specific conference. Often new users are confused about this and may receive some unsavoury mail from more experienced users.

With the increasing cost of forwarding messages between systems it is important that discussion between users is restricted to conferences that are only carried for the intended audience. For example, a discussion of a Victorian training course would only interest and concern readers in the state of Victoria. It would it be wasteful and distracting to send this message in an Australian or international conference.

MINIMISING JARGON

To help the users understand what is being displayed, we attempted to minimise the jargon displayed to the user as much as possible by using other words which students and teachers would understand. For example, conferences that are distributed among several computer systems are called echomail on FidoNet systems. Instead of telling users what echomail is, we used the audience of the conferences for identifying the conference types.

One of the more demanding concepts to learn, use and understand on the mail point is the Direct Private Mail conference (technically known as the netmail). This conference serves two purposes; to send messages directly to other Fidonet systems, or to send messages to the Internet gateway.

We found the best approach was to break up the problem into the two areas; FidoNet Netmail and Internet Mail. We made a small sub menu that would be displayed to the user after selecting the option to enter a message in the Direct Private Mail conference. The sub menu asked the user to select from the two types of messages, and then it would give an example of how to write the type of message chosen and would automatically key in data for them where applicable. Students and teachers found this a much more effective way to write either of these sorts of messages.

CONSISTENCY

We decided early on that a desirable interface for our mail point should not confuse the new user, require the memory of many varied and obscure codes or functions (Schneiderman, 69-71). We made each screen look similar by using the same coloured boxes and text and used consistent keystrokes.

Adopting a successful pattern used by various applications and on-line bulletin boards, we used a consistent set of menu options that would work from any menu. For example;

Key	Description
*	Returns to the main menu
-	Returns to the previous menu
?	Gives the user some helpful information
!	Log Off and Exit the Mail Point

To help the user memorise keystrokes, we made the first letter of each menu option description the keystroke to execute the menu option where possible. For example, after a user selects a conference, they could press R to read messages in the conference. The keystrokes to execute each menu option are also highlighted to emphasise the key to press.

USING THE MAIL POINT

TEACHING STRATEGIES DEVELOPED WITH YOUNGER STUDENTS

An interesting challenge and one of our objectives was to improve and design access for primary school students aged from 7 to 12 years working in pairs on the computers.

It became evident that a different approach was needed and some observations and strategies that worked well are;

- The students learn the procedures to log on to the mail point by writing down the procedure each time. Although this may seem only a simple procedure containing a few keystrokes, it can be daunting for the younger students to be able to spell their name and password correctly and then navigate themselves through the menus.
- Before each lesson the students write the message they are going to write on paper first. This way the messages can be checked by the teacher for spelling and punctuation mistakes before they are sent. It also ensures that the students have something to write during the time they have to use the mail point.
- When the students are using the mail point, they work in pairs. One student can log on to the mail point and read and reply to messages, whilst the other student acts as a proof reader and offers suggestions to their partner. Once the first student has finished, the students swap places and the process is repeated.
- Parents are great helpers initially when the children lack confidence and need close supervision. Parents can also ensure the success of a mail point by their help and support.
- As each message is posted by a student, they are printed (by pressing "print screen") so that they have a permanent record of what they have sent. This also gave them something to show their parents at home.
- The mail point provides a good way to get the students to practise their writing, spelling, punctuation and readings skills without realising it.
- To ensure that all students would have mail to read next time they log on, the teacher would write each student a message. It is disappointing for students when they don't receive any messages, but they find it exciting when they do receive messages.
- Students have to be watched carefully to ensure that they post their messages in the appropriate conferences.
- For the mail point to be a success, teachers have to be dedicated and enjoy using the mail point. If the teachers enjoy it, so will the students. The students need as much enthusiasm and encouragement which the teacher can offer.

NETWORK BEHAVIOUR AND ETIQUETTE

Teachers need to promote good constructive network behaviour or etiquette. Language used by students must not get out of hand and they must honour the published rules for activities and discussion conferences.

Teachers do not need to read every message in all the conferences supported as each conference has a person called a moderator whose role it is to regulate topic discussions, enforce the conference rules and answer any questions. For example, for the Senior Chat conference on K12Net, the rules are:

From : Bob Shayler
To : All
Subject : K12_SR_CHAT Guidelines

K12_SR_CHAT Access Guidelines

1. NON-ABUSIVE LANGUAGE ONLY:
Use friendly and non-abusive language when typing messages. Posting a message which includes any racist or slanderous language is not allowed. Posting a message which is slanderous or libelous toward either an individual person or a group of people is not allowed The reader of your messages cannot see you as you "speak," so the usual visual clues and your tone of voice can't be used by the reader to distinguish a joke from an abusive statement.

2. NO FLAMING OR PICKING FIGHTS:
Flaming (picking or participating in a verbal fight) and profanity don't belong here. Calling a person a name or attempting to intimidate a person is not allowed. This conference is here to encourage people to meet each other and make friends, not to support verbal brawls.

3. NO CUTE FORMATS AND ABBREVIATIONS:
Using cute keyboard symbols like "*&$#" doesn't hide the meaning of words which are inappropriate here. Creating blank screens or including control characters in messages to create "cute" screen displays are in fact irritating to most readers and can even cause software problems. Write messages formatted in a normal fashion with usual spelling of words.

3. DISCUSSIONS ABOUT SEX RESTRICTED:
Certain subjects, no matter how important or common in everyday private conversations, can become inappropriate in this open conference medium depending upon the

sensitivity of the message. Messages which include specific discussions of sexual practices and techniques are not permitted here.

4. NO PERSONAL ADDRESSES OR PHONE NUMBERS:
   Unfortunately, there are people with modems who may send you stuff you won't like if you post your home address and phone number. If you want to exchange regular (written on paper) mail, use your school address for at least the first mail.

5. NO PRIVATE MESSAGES:
   ALL messages (mail) you write to people in this conference are read by EVERYBODY not just the person you are writing to. Writing to Jane about her ex-boyfriend John may have been intended as a PRIVATE message but guess again. Everyone can read it!

   If you want to write to someone PRIVATELY, then you must write a message in a PRIVATE MAIL conference or NETMAIL. It is up to the sysop of your local K12net BBS whether private messages and/or netmail are available to you, so contact your local sysop about these possibilities.

6. IF YOU DON'T LIKE THESE GUIDELINES:
   If you don't like these "guidelines," write me a polite and reasoned message (netmail if you can). These "guidelines" have and will evolve over time and with experience. But do not violate these guidelines, else you may lose your access to K12net!

-Bob Shayler-

Figure 4 : K12 Senior Chat Rules

If any conference rules are breached, a moderator can directly write to the offending person and the system operator. Continuous re-offenders can be denied access.

Mail points will invariably support conferences available only to users of that system (known as local conferences). In order to moderate students' writing in these conferences, two older and responsible students were made local conference moderators. They regularly read all the local mail and report any problems to the system operator.

LOCAL MODERATOR RULES

A local moderator is a appointed by the system operator to monitor an allocated conference. The moderator is responsible for the messages which are written in his/her conference.

A local moderator should:

1. Read all new messages in the conference which he/she is responsible for.

2. Be seen as just one of the users who is trying to help all participants get along with each other.

3. Respect a user's privacy if the user has written a private message to another user.

4. Patrol the conference he/she is in charge of for abuse. For example, obscene and inappropriate language or users who are personally attacking other users.

5. Forward any messages considered inappropriate to the system operator so that the system operator can deal with the user(s) involved.

6. Do not abuse your privileges.

7. .If in doubt about anything, discuss it with the system operator.

Enjoy Moderating!

Figure 5 : Local Moderator Rules

A principle concern held by many teachers when allowing students to use electronic mail is that the language used by students might get out of hand. To help overcome this fear and save the system operator from manually checking all the messages posted, a program was developed that could scan all the conferences. This again took full advantage of the relevant file formats being available.

The obscene language scanner scanned conferences for any message entered that contains words or phrases designated as obscene by the system operator. If an offending message is found by the scanner, it is deleted and forwarded to the system operator for review. This program has been extremely useful and has prevented many potentially unsavoury incidents occurring.

Conference rules, local conference moderators and mail scanners help to encourage positive network behaviour amongst all student users.

PROFESSIONAL AND TECHNICAL SUPPORT

Many educators have expressed interest in the mail point idea, but few have dialled up or used an online service of any sort. The mail point makes it easy for the user, but the system operator needs to have a grasp of some sophisticated functions. In order for users to grow in competence from a novice user to the relative sophistication of a mail point operator, a focus and structure would need to be provided.

This has been conceptualised in the form of STEM (Students, Teachers and Electronic Mail): a loosely organised group of primary and secondary teachers, university lecturers and tertiary students who have a common commitment to promoting the use of electronic mail and computer conferencing for teachers and students in both primary and secondary schools. STEM is associated with the Bennettswood Technology for Learning Centre of Deakin University, which provides an organisational base for the provision of professional development programs, short courses, consultancy services, teaching resource development, and study and research opportunities.

ANALYSING TRENDS IN THE USE OF COMPUTER MESSAGING

Previously, we reported unsubstantiated survey evidence that there might difference between boys' and girls' use data was sought. As is typical of bulletin board software, the system we are using (Ezycom) maintains extensive files on user statistics and activity, and all manner of information on the messages available on the bulletin board. This information tends to be stored in package-specific formats. Taking full advantage of these file formats being available, software has been developed to archive periodically the system activity into a more common and more easily manipulated format: that of a set of DBASE files. This format allows for an initial investigation and later it may prove useful to generate data for analysis programs such as SPSSx or NUD-IST.

Using such information sampled several times over an extended period, gender differences in the use of this electronic messaging system will be investigated. Important differences between other groups of users could also be investigated, such as younger users compared with older users.

CONCLUSION

The mail point concept has, for the people involved, strengthened the links between primary, secondary and tertiary education. It has also empowered teachers to see themselves as researchers. The most profound effect of the mail point initiative has been the endeavor by all concerned to embark on a program of systematic improvement. The impact has been felt on the technical operation of the system, the desire to improve teaching and classroom practice and to more fully understand the implications computer communications will have on the lives of young people, their teacher and their schools as we move towards the 21st century.

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SO NOW WE HAVE A NATIONAL K-12 CURRICULUM: WHERE DO WE GO FROM HERE?

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The announcement of the development of a National K-12 Curriculum, "Technology for Australian Schools Interim statement" in 1992 is the motivating force behind this paper. The concept of a National Curriculum has profound implications on the Teaching Profession in general and Pre-Service Teacher Education in particular. This paper is intended to play the part of the devil's advocate by asking questions such as: What or whom is behind the curriculum? and Where are the resources to implement it coming from? By introducing controversy, its aims are to stimulate discussion and action by teacher educators.

In addition to 'putting the cat amongst the pigeons' this paper presents a developmental model of a definition for computer literacy and lays the groundwork for the inclusion of a model CIE curriculum into the National K-12 Curriculum. This developmental model is offered as a starting point to focus discussion and perhaps the formation of a body of experts to expedite the means to put into place a workable, agreed-upon curriculum that will assist all educators in Sharing the Vision of quality education in Australia.

In 1988 an enquiry was conducted by the Standing Committee on Employment, Education and Training (SCEET). The enquiry recognized that advances have been made in the use of educational technology, but noted that such use is however fragmented and without an overall direction. The evidence presented highlighted the lack of experienced practitioners at all levels of education and noted that there are very few people who have the expertise and the experience to implement programmes and conduct research in the area of Educational Technology. (SCEET 1989 pp. 76-77)

The results of the enquiry motivated the Australian Government to commission a study into the development of a National Curriculum for K-12, highlighting technology in the school curriculum. At the ACE '92 Conference in July of 1992, 'Technology for Australian Schools' (AEC 1992), an Interim statement was publicly announced in the guise of a 'Forum'. fo •rum: a meeting or assembly for the open discussion of public interest.

It could be argued by some the presentation was anything but a 'Forum', as no time was allowed for discussion or questions from those attending. To add to the frustration of not having the opportunity to ask questions, at the time of the announcement, the Interim Statement was "in press" and no copies were available for perusal by those attending the 'Forum'. Subsequent release of the document still leaves many questions to be answered.

Foremost is the question, What implications has the K-12 Curriculum on current pre-service teacher education curriculum? The teaching of Technology requires vast resources if it is to extend beyond the theoretical. In the current economic climate, Where are the resources coming from? Funding at all levels of education has been cut. K-12 Schools are being told they must take on the responsibility of supplementing funding by securing sponsorship. Higher institutes of learning must supplement their income by securing research projects as well as sponsorship.

Where are the resources to finance the establishment of the K-12 curriculum to come from? Is the Department of Employment Education and Training (DEET) going to supply them or are they going to come from benevolent benefactors that will surely secure their pound of flesh in return?

Certainly if the Technology Curriculum is to be taught at the K-12 level, to be effective, the delivery system must first be developed at the highest level. Two areas of study have been targeted to establish the Technology Curriculum. Home Economics and Design and Technology are being forged together to become the centre of Technology Education; a large task for a small group of educators.

Where do the rest of the educational disciplines fit into the scheme of things? The extent of influence technology will have on the overall curriculum is indicated by the goals set out in the document. The AEC considers them to be the "Common and Agreed National Goals for Schools in Australia". (AEC 1992)

Although the document clearly sets out its goals and objectives for technology, it is not clear as to what its relationship is to the overall curriculum. It raises questions and concerns as to how it fits into the basics of education - reading, writing and mathematics.

Hopefully, the final statement by the AEC will place the National Curriculum into perspective and put to rest the concerns and answer the question:

- Will technology dominate the curriculum or be a core that runs through it strengthening all disciplines?

The question, "Will technology dominate the curriculum?" is not a new concern. Hall made an observation:

> We are preparing teachers today for a future where technology may be rampant; our education studies need to take this situation into account. ...In developing teaching strategies preservice students will be required to know how to effectively use this new technology to enhance the educational experiences of their charges. (Hall 1984 p. 21)

To this point in time little has been accomplished in the development of teaching strategies for preservice students to cope with the accelerated developments in technology. The National Curriculum for K-12 appears to be addressing Hall's observation by putting into place strategies to overcome the shortfalls in the present educational outcomes. The absence, however, of a clearly-stated relationship to the overall curriculum, brings about concerns as to the dominance of technology over the total curriculum.

In a 1985 paper Ash stressed the need for strategies in the development of a Computers In Education (CIE) curriculum and to be more critical of fads and trends. Seven years after his presentation, his words echo:

> ...Teachers and administrators, parents and school boards, all need something to go on to make the decisions they have to make about goals and curriculum. And if no one else does it, the taxpaying public may soon demand an accounting. Let us start planning before it is too late. (Ash, 1985, p. 39)

It may well be too late to take control of the Technology curriculum to ensure that as Hall commented in 1984:

> ...There is a need for more teacher educators to become actively involved in helping present and future teachers to understand the benefits and dangers associated with technological developments, both in the educational context and in society in general. There is a real possibility that if we do not take up this challenge some learner's educational experiences may become computer dominated; dominated by the wiles of the commercial world, assisted by short sighted bureaucratic expediency and pseudo-efficiency, and permitted to take place by a teaching profession ill-prepared to counter the technological bandwagon. (Hall, 1984 p. 23)

It would appear the bandwagon in the form of the National Curriculum has started to roll. The question is, Who is driving the bandwagon? Is it the "commercial world, assisted by short sighted bureaucratic expediency and pseudo-efficiency", or is it going to be a well informed, well trained, teaching profession?

Rosenberg, in a 1989 study, found evidence of the involvement of the "commercial world" in the promotion of computer literacy. They could be the most significant beneficiary of the computer literacy movement:

> The single theme encountered most often in my discussions with teachers about computers is their strong sense of being pressured to use computers in class. The pressure comes from several sources that interact with each other to form a complex web of social forces. ...the developers, manufacturers and retailers of computer-literacy materials ...have an economic incentive to encourage the education establishment to buy into computer-literacy education. "We're looking at an infinite market," said the chairman of one computer-manufacturing firm. (Rosenberg 1989)

There is no doubt that computer literacy is important and the "commercial world" has a part to play in it but that role must be brought under control by education.

With the bandwagon metaphor firmly in mind let us view the role technology has to play in education. Undoubtedly the role technology has to play in education is an important and necessary one. However, if technology is applied without controls, the learner's educational experiences could easily become technology dominated and "the technological bandwagon" may crush education as we know it.

Today, the core of technology is undoubtedly the computer. The computer plays a major role in the development of virtually all new advancements in technology. This is emphasized in the 'Interim Statement' by the amount of computer associated content proposed in the K-12 Curriculum. The document outlines four strands of learning in technology:

The four strands of learning in technology set out in this statement are interdependent.

They are:
- designing, making and appraising;
- materials;
- information; and
- systems(AEC 1992 p. 5)

With a large percentage of the curriculum devoted to "The techniques of gathering, sorting, storing, retrieving and communicating information..." (AEC 1992 p. 7), the information strand emphasizes the role CIE is to play in the curriculum as a substantial one.

So now we have A National K-12 Curriculum for Australia, Where do we go from here? Hopefully the AEC, DEET and the Federal Government will come to the party and answer the questions asked above. In the meantime we must gather the few who have the desire and expertise in CIE, develop a suitable curriculum for pre-service teachers and mount the bandwagon before it's moving too fast to get on board.

It is imperative CIE educators move swiftly to develop a suitable means to address the needs of pre-service educators who must fulfil the requirements of the National K-12 Curriculum. As definitions and standards play an important role in the advancement of a solid and workable curriculum it's time thought was given to establishing an national agreed-upon definition of computer literacy to assist in the development of a sound National Technology Curriculum.

With the development and establishment of sound curriculum in mind the following is offered as a starting point to focus discussion and perhaps the formation of a body of experts to expedite the means to put into place a workable, agreed-upon curriculum that will assist all educators in Sharing the Vision of quality education in Australia.

In a paper outlining the problems of developing a Computer Literacy Curriculum, Duckett (1992) presented Moursund's definition of computer literacy (Moursund 1983) in a modified version. See also (Moursund 1992) The modified version of Moursund's definition:

1.Knowledge and skill in operating a computer using a library of generic programs as determined by each discipline's requirements.
2.Knowledge of various ethical and social issues, in general, and in greater depth issues determined by each discipline, relating to computer use.
3.Knowledge and skills in computer programming using a high level language as deemed appropriate or not by each discipline's requirements.
4.A functional level of knowledge for the use of computers as an aid to problem solving, and roles of computers as a source of problems as deemed appropriate by each discipline students study in school.
(Duckett 1992)

To further test Moursund's concept, Duckett describes in a subsequent paper the steps he used to further refine the computer literacy definition. The following are segments from that paper.

A short discourse was assembled and sent out to a number of discussion lists on the BITNET listserve. Twenty responses were received... The respondents were lecturers and Graduate Students - not a very large sampling but a rewarding one.

Moursund's concept of computer literacy stood up very well to criticism in all but one area... Item 3 of Moursund's definition however is a different matter. There is a strong divergence of opinion that hinges on the term 'Literacy'. Computer Educators emphatically hang on to the concept that to be computer literate a person must be able to read and write one or more high level computer languages. The 'rest of us' however feel that the ability to be a competent, computer user is sufficient to be computer literate.

Attempts to define computer literacy in global terms have met with little success due to the diversity of requirements by each discipline with a vested interest in the subject. It would appear the heart of the controversy rests on the interruption of the word 'literacy'. One faction looks at literacy in literal terms, the ability to read and write computer programming languages, while the other sees it in broader terms of understanding and functional ability; another will see it in narrow technological terms while others see it in a broader combination of technical and social issues. Then lastly there is the debate that everyone should be Computer Literate, not only a select group.

In global terms, to be Computer Literate a person would:

> have comprehensive skills, knowledge and understanding of computers and their use as they relate to technical, ethical, social and educational issues of the day, as deemed appropriate to the skills, knowledge and understanding required.

As each discipline of study has specialized requirements, a global definition can extend no further than stated above. It is therefore the responsibility of each discipline to define:

> the extent of skills, the level of knowledge and understanding of the use of computers, to be determined by each discipline, within its sphere of influence.

With this as a definition, a move to clarify the requirements for a pre-service teacher to become computer literate was undertaken.

Four key subject areas have been identified.
1. Technical
2. Ethical and Social
3. Educational
4. Specialised Developmental or Computing

The key subject areas relate directly to what is seen to be required at this point in time by a person entering the teaching profession.

Items 1-3 represent the core units for all pre-service teachers. Item 4 is basic for the study by pre-service teachers to whom the knowledge of computer programming is part of the discipline's requirement.

1. **TECHNICAL ISSUES:**
Knowledge and skill in operating a computer using a library of generic programmes.
a. the computer, its system, network and peripherals as to what they are, how they work and how they can be used as a teaching or learning tool.
b. use of an integrated software package appropriate to the platform/s, taught or used, to include word processing, graphics, database, spreadsheet and communications.
c. the knowledge and ability to monitor the rapid changes in technology enabling educated decisions to be made when required.

2. **ETHICAL AND SOCIAL ISSUES:**
Knowledge of various ethical and social issues relating to computer use.
a. the legal and ethical aspects of copyright law and what constitutes computer crime.
b. the social and ethical issues of the impact of computers on society as applied to the gathering of personal data, impact on employment, education and many other issues that exist and will manifest themselves with the expansion of technology.
c. the knowledge and ability to monitor the changes in social issues related to changes in technology.

3. **EDUCATIONAL ISSUES:**
A functional level of knowledge for the use of computers as an aid to problem-solving, and the role computers play as a source of problems.
a. when a computer is a tool and when it's a problem.
b. computer anxiety and the means to overcome it or present alternatives to using the computer.
c. evaluate and determine what educational or other software is best suited to the task at hand.
d. knowledge and skills in instructional systems design as well as the ability to prescribe the integration of computers into a study discipline.
e. methods used in problem-solving as they relate to the educational use of computers in the curriculum.
f. ability to monitor the changes in educational issues related to changes in technology.

4. **SPECIALIZED DEVELOPMENTAL OR COMPUTING ISSUES:**
Knowledge and skills in computer programming using a high level language.
a. programme languages in relation to use in the development of software relevant to requirements.
b. methods used in problem-solving as they relate to programme languages.
c. use of specialised authoring, multimedia or statistical software packages. (Duckett "in press")

The above not only suggests a definition of computer literacy for teacher education but lays the groundwork for the development of a model CIE curricula.

Once again we must ask the question, Where do we go from here?

From one point of view: If higher education is going to meet the needs of Australian social and economic needs in the next century we must address the ways and means to accomplish them. The use of technology and communications are one of the most important means available to accomplish the task ahead of us. Serious thought must be given to developing the expertise of our teachers, using the technology currently available to us, by arming them with enough knowledge and ability to cope with the challenge expanding technology is putting on the shoulders of educators.

Some hard decisions need to be made as to how technology is going to be fitted into an already overloaded curriculum. Decisions must be made and they must be made soon. We are faced with two alternatives. One, find a way to fit technology into the existing educational undergraduate curriculum and give each graduating teacher at least the basic knowledge needed to deal with technology. Two, establish a new undergraduate, specialized, educational discipline for Technology and Communications. The latter should not be confused with the new K-12 Technology Curriculum.

This enlightened body of Educators is aware of the need to incorporate technology into the educational process. Your presence at this conference is an indication of your concern of the need to do so.

Technology and Communications is the instrument that will enable education to flourish in the coming century. If education is to reach the heights necessary to fulfil the demands placed on it by society, we must play a role in seeing that Technology and Communications takes its place in the curriculum.

To answer the question, Where do we go from here? , obviously, some action must be taken. Each and every one of you that is aware of the importance the role technology plays in education must become active in promoting and encouraging it. The professional bodies, of which we are members, must take up the challenge and establish committees or working parties to address the problems that face the introduction of Technology and Communications into the curriculum. This means you must take an active part in establishing these committees or working parties. Surely if we don't take an active role in the development and establishment of the Technology and Communication, you can be assured sooner or later someone else will, and it may not be to your liking!

If you wish to take part in "Sharing The Vision" of establishing a comprehensive Technology and Communications curriculum, write to your Professional Organization and make your contribution.

If you don't belong to a Professional Organization and you have a desire to add your comments or ideas to the subjects covered in this paper, please do so by sending your remarks to:

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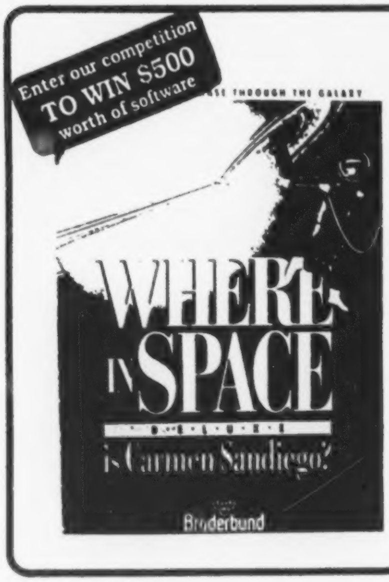

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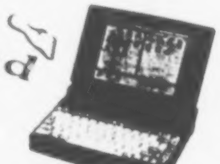

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COGNITIVE MODELLING IN INTELLIGENT TUTORING: INDIVIDUALISING TUTORIAL DIALOGUE

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This paper discusses the importance of cognitive modelling as a means of personalising student-computer dialogue in intelligent computer-based tutoring. Computer assisted instruction (CAI) and the limitations of traditional programming and authoring in accounting for the knowledge state and acquisition of skill have led researchers to look for new methods in programmed instruction. Intelligent tutoring systems (ITS) are introduced and compared with traditional CAI. The student modeller component of an ITS is based on a theory of cognition and attempts to trace student understanding through various methods. Such systems have been devised in a number of domains, examples of ITS in mathematics and computer science are detailed. Approaches to model tracing tutoring include plan recognition and feature-based modelling, which are structures to determine student understanding and provide appropriate assistance. Desirable features and fundamental principles of a model tracing ITS are suggested.

INTRODUCTON: THE LIMITATIONS OF COMPUTER-BASED TUTORIAL INTERACTION

Since microcomputers were introduced into schools in the early 1980's one of their important uses has been as a teaching tool through the use of educational software. Some of the tutorial software, or courseware, over the past decade has been little more than a screen by screen presentation of content with questions which, when correctly answered, progress the student to the next screen of information. A common complaint has been an inability to adapt to the particular learning needs of the student user. An experienced teacher would know from the individual responses of the student which aspect of the work requires repetition, how explanations can be restated and what questions to put to the student before additional material can be given. The teacher can be considered to have developed a cognitive model of the student, that is, a concept of the learner's current knowledge in the subject domain, and has at his/her disposal a variety of teaching strategies to be employed depending upon the student's responses and the nature of the information to be presented. The tutor works with a student model, a teaching model containing strategies for effective teaching, and an understanding of the lesson content including the relationships between the component parts in the knowledge domain, and is able to make adjustments to the flow of the tutorial by responding to the student. By contrast, tutorial software is often inflexible, using a simplistic learning paradigm which offers too few possibilities for branching depending on student responses.

Certainly the potential of courseware to interact with the student has improved over the years, largely because designers of such software can write for more powerful computers. Most schools now have computers which can provide excellent graphics, mass hard-disk storage, several megabytes of memory, and sound capabilities. Developments in peripheral devices such as CD ROM provide scope for developers of educational software to encode more complex routines using this more interactive media. Multimedia has enhanced the cognitive flexibility of computer based learning through its ability to restructure knowledge presentations to meet changing situations. These new features of microcomputers have become available in a very short time, and affordable hardware continues to develop at startling rate. There is therefore good reason to think that the capabilities of tutorial software written for the next generation of school computers will far exceed today's standards, and provide a platform for a far more natural discourse between the student user and the computer. However, the success of the media to teach effectively relies as much on its ability to parallel the cognitive processes of the learner through tracing the student's acquisition of knowledge as it does on its ability to present the lessons in a stimulating and interactive way. The improvements in computer hardware, interface design and multimedia presentation have not addressed the problem of providing the computer with an understanding of the student user.

One of the problems in making computer software more individually interactive and the student-computer discourse more natural is that as more branching capabilities are required to meet the enormous number of possibilities in student responses, it becomes slow and limited. A great deal of coding is required at each stage to account for an enormous variety of possible responses from the student, and as a result courseware written using traditional programming techniques becomes cumbersome. Authoring software has provided educators with experience in the design of courseware. Programs such as *Hypercard* and *Authorware Professional* are a purpose-built user interface specifically intended for the design of educational material, and enable the designer to encode complex display and branching on student responses. While these packages require a special expertise to be used effectively, such software has given educators rather than programmers a major part to play in the development of educational software. *Hypertext*, the underlying language of the program Hypercard, has demonstrated the power of an associative information structure as a realistic alternative to a sequential or hierarchical traversal of the subject matter. While it is said to more closely model the criss-crossing of information often found in learning, the programming required to allow high levels of flexibility remains daunting. Also, while designers of educational courseware have found this flexibility an exciting challenge, it can also be too liberating and unstructured. Certainly it is easy to create a Hypertext 'spaghetti' using Hypercard, where the links between the screens, buttons and user responses can quickly become quite complex. Because of the complexity of the student-computer dialogue different techniques in programming become necessary.

One approach to student centered computer assisted instruction has been the creation of microworlds, of which *Logo* is perhaps the most well known example. Here the computer provides a friendly language for the student to carry out investigations, and the computer responds to commands in a precise and predictable way. To an extent, the problems of accounting for an enormous variety of student responses are overcome, as the language is rigid and predictable, providing only a enquiry shell for the student to investigate relationships and test theories. The resulting dialogue is initiated by the student, and the computer has no record of the student's progress or understanding. Such environments provide the student with the basic tools for interaction but the computer does not gather information about the student from the dialogue, that is, it does not trace the student's learning. The computer is passive, and learning takes place at the student's initiative. Swan (1989), has suggested that students do not automatically develop problem solving skills through learning to program with Logo, but can develop such skills through programmed instruction on Logo. He thus argues that..."Explicit instruction and mediated programming practice..." (Swan, 1989, p.281) is the only means of supporting the development of problem solving strategies, and the distinction in terms of instructional modelling is the difference between discovery learning and a model of explicit instruction.

While this paper primarily discusses intelligent tutoring that provides structured, individual tutorial interaction, it is interesting to note that some artificial intelligence has also been added to microworlds. A number of intelligent discovery environments have been created and the distinction has been made between *AI for teaching* where the system has to partially model student-teacher interaction and *AI tools to assist learning* where the learner's cognitive activity is extended and enhanced (Bergon & Paquette, 1990). Student-centered learning microworlds such as Logo may be classified as a tool to assist learning.

INTELLIGENT TUTORING AND CAI

For a tutoring program to be classified as "intelligent" it must adjust the content and delivery of the lesson to the needs of the student by analysing responses. It can do this by tracing the path of the student's understanding through the subject matter. Intelligent Tutoring Systems (ITS) developed from Computer Assisted Instruction (CAI) along with the advent of Expert Systems. An ITS is usually implemented through an expert systems shell (Valley, 1989; Major & Reichgelt, 1989). Put simply, an Expert System consists of the knowledge area itself, in much the same way as a database contains information; a list of rules and principles; particular exclusions; general inferences; and special cases and categories. Useful knowledge is, after all, more than a collection of facts as found in a database, but also a set of relationships, restrictions, interpretations and inferences between the elements of the information. Generally an ITS consists of four abstract components: A *Reasoner* or problem solving mechanism such as an expert system; a *User Modeller* which traces the students responses and assesses the student's current level of understanding; an *Interaction Manager* which controls communications between the student and the computer; and a *Tutor* which contains the instructional strategies used in the actual teaching. Each of these components may be a separate expert system, linked to create the impression of a highly adaptive software program. In an effective ITS, each of the component structures will be based upon sound educational theory: the User Modeller's means of re-ordering rules on student responses, the Interaction Manager's ability to present the material in an interesting way, as well as the Tutor's instructional strategies. While a number of ITS have been developed on mainframe computers, and writings on Intelligent Computer Assisted Instruction (ICAI) will often contain extracts from actual dialogues with such systems, they are not commonly implemented on microcomputers that are used in schools. Until recently, such systems had largely remained the domain of the computer scientist, writing specialist software for research.

One of the most important features of a CAI program is its interactivity, and the computer is seen as the vehicle through which certain teaching techniques may be used and enhanced. ITS programs are knowledge centered as they are based on a well-defined model, and ITS developers are interested in a set of instructional principles general enough to apply to a variety of teaching domains. Thus ITSs have developed from instructional theories, and research in this field helps understand the relationship between the learner, the content and the instructional strategies. By comparison, CAI programs are usually not based on a single instructional model, but are often a collation of techniques which attempt to engage the learner in the tutorial interaction. Many CAI programs reflect the attitudes and ideas of the developer about the manner in which the material should be presented, and these in turn are often derived from aspects of the nature of the medium itself rather than on a principle of teaching and learning.

INSTRUCTIONAL PRINCIPLES AND ITS DESIGN

An ITS generally performs its teaching in accordance with a well-defined instructional model which is capable of solving the problem as an expert would. This is often known as a *performance model*, and is capable of keeping track of the student's progress through the maintenance of student knowledge tracing. The performance model in the ITS consists of a set of rules called *productions*, which are essentially steps in the problem solution and the conditions required to apply the steps. The productions are not applied in any specific order, but after each step in the problem solution, the program finds possible routes to the solution and identifies the rule which adds most to the situation. The teaching model takes care of the flow of the material and remediation, and varies instructional strategies, while also maintaining a clear picture of the student's knowledge state or current understanding. Mistakes are identified when the student makes an explicit error or persues a path that will not lead to a correct solution, and remediation may follow.

Brown (1990) and other writers (Anderson, 1992; Corbett & Anderson, 1990; Swan, 1989) have explained how current theories and architectures in ITS have impacted upon learning theories, and vice-versa. Brown makes the distinction between *explicit cognition* (practice) and *implicit cognition* (theories), and draws parallels between the ways that students learn outside school (by experience, demonstration, problem solving in practical situations), and in school (through formal reasoning and abstraction). The analogy is extended further to *everyday cognition* (typically those types of processes in which one would engage in the course of ordinary living) and *expert cognition* (the ability to abstract problems in order to solve them). The implications for the design of ITS are set out in a series of necessary features of the learning tools which support this new epistemology. These are briefly: To model the way people react with their environment; to reflect the environment and allow problem solving; support shared conversations and investigations; allow issues and problems to emerge from the investigative activities; allow the reflective process of human mental modelling in problem solving (Brown, 1990, p. 278-279). The goal of the learning tool is to create a *glass box* which not only connects users to the world but allows transparency of the domain and the tool itself.

Brown's assertion that theories of learning and ITS design are related is supported by Anderson (1990), who believes that there is considerable research in cognitive psychology which can be used as a guide to the development of ITS. He states that the success of an ITS can depend on its ability to achieve 'task decomposition', a process of simplifying learning, and the monitoring of student's belief by generating production rules (task analysis) for a restricted knowledge domain.

COGNITIVE MODELLING ITS

The key to the power of an ITS to individualise instruction in tutorial courseware lies in the way it models the cognitive processes of the learner through *model tracing*. To do this, it is necessary to develop a cognitive model of how the student should solve problems and use it as a guide through the coursework. Then, supplement the model with errors that the students are known to make. Comparing the student's steps to that of the student model is known as model tracing. When errors are made, feedback is provided. This is a step-by-step model tracing methodology and interpretation of behaviour in terms of cognitive rules, and monitoring the students acquisition of rules and provides the basis for tailoring the tutorial interaction to the individual needs of the student. The approaches of a number of ITS to student modelling are explained in the following pages.

MATHPERT

Beeson (1989) has detailed MATHPERT (MATH exPERT), an expert system in mathematics with extensive capabilities, supporting learning in algebra, trigonometry and introductory calculus. It provides step-by-step solutions, tailoring teaching methods and step size to individual users through student modelling. It provides an illustration of *tool transparency* in an ITS, as it differs from other computer tutors in mathematics in that it is a *cognitively faithful* and glass box system. This means it solves problems as students would, with the routines being transparent to the student. MATHPERT works by the translation of the subject material into several hundred operators. In one mode the user chooses the next operator, and in automatic mode the system chooses it, generating parts of the solution by itself. The system will apply operators well-known to the student straight away, and the system learns to identify which of the operators are familiar to the learner. The operators themselves are chosen so as to correspond to familiar concepts, making the system cognitively faithful. Operators such as "collect powers" for example to correspond to x2. x5 = x7 The student model is first initialised by a program called DIAGNOSER which creates the model from the first session, generating problems interactively, depending upon the student's responses. The model is continually updated by a program called EVALUATOR which decides when the status of an operator should be upgraded from *learning* to *known*.

MATHPERT does not allow an incorrect step, thus it may be said to be founded upon the Montessori principle of "control of error" where the student is immediately informed of mistakes. This is opposed to the "buggy model of learning" in which the computer diagnoses the student's mistakes and based on the errors initiates a tutorial to correct the misconceptions. The underlying principle here is that if students are not permitted to make mistakes, the whole process of diagnosing bugs is unnecessary. Self (1990) proposed an ITS without a student modeller as a means of "bypassing the intractable problem of student modelling" (p. 108). It has been argued that in good teaching, misconceptions are avoided and mistakes are immediately corrected, and this negates the requirement for a student or user-modeller, which can be difficult to construct and expensive in terms of computing time to build into a system and maintain. Self (1990) argues that the role of student modeller is essentially to analyse student errors and misconceptions. From a catalogue of possible allowable responses to a question, the modeller attempts to create a list of associated misconceptions. The user-modeller may be given the important role of analysing student performance in terms of the *conceptual* mistakes being made rather than just identifying mistakes, as well as altering questions that follow and evaluating student performance. This is yet to satisfactorily be implemented in a working ITS in a non-trivial domain. The problem has been that programming these misconceptions has been more difficult than merely identifying a mistake. These problems have led Self (1990) to declare that it is not yet possible to build into a working ITS all the modelling features that designers suggest, but perhaps the most important considerations are to build a modeller in an ITS that provides natural, reliable and simple interactions; link the models with outcomes in the tutorial process; use the model not solely as a error-handling feature of the ITS; use the model as a set of beliefs and allow the tutor to modify the set in a helping way to improve student understanding; make the model transparent to the student; and to create modeller's which work collaboratively.

LISPITS

Corbett and Anderson's (1992) description of the LISP Intelligent Tutoring System, namely LISPITS, which instructs students in the programming language of LISP, is based on theoretical principles derived from a theory of cognition proposed by Anderson known as ACT (Anderson, 1983). ACT theory proposes that human problem solving is enabled by a set of production rules, and can be turned into a formal set of well-ordered rules about instruction. Briefly, this is that behaviour is goal-driven; that there is a distinction between declarative and procedural knowledge; that the acquisition of procedural knowledge occurs through a sequence of productions of a declarative nature, which through repetition and practice are collated into larger productions; and finally that in the early stages of learning a *working memory* is needed before productions are built.

The student modeller in LISPITS is needed to meet the design criteria established by the principles above, and is essentially a pattern against which the student's behaviour can be measured, allowing the tutor to determine if each step in the student's input is on a path to the solution. While it is possible to have a catalogue of possible solutions, it is difficult to explain the steps to students in terms of the problem solving procedure, or in terms of underlying goals. That is, how the step relates to the other steps and the solution of the overall problem. LISPITS has a set of rules for problem solution and a specification for each exercise, rather than a solution for each exercise. The tutor is thus able to simulate the actions that a expert would take at each step in the problem. The tutor compares the student's response to the set of possible responses and known errors, and so can tell if the student is on a path to the answer. The complete set of rules for solving problems is called the *ideal student model* and represent explicitly the instructional objectives. The student model also contains a catalogue of errors and misconceptions also called the *bug catalogue* or *student model buggy rules*. LISPITS uses the finest grainsize (Greer, 1992) as it analyses individual characters students enter. It works from top-to-bottom and left-to-right, and provides immediate feedback after errors are made. The tutor's behaviour is linked to the student model which consists of over 1200 rules. The model tracing is implemented by *model compilation* where the model is run prior to the execution of the program, and this saves on computing power which is limited given the extent of the pattern matching required to determine possible paths at each subgoal in the problem solution. The student model is run ahead of time, allowing the computer to generate all paths that lead to the correct answer and save them. This is an alternative solution to the problem of encoding a student modeller component of an ITS which is less drastic than eliminating the modeller from the design altogether (Corbett and Anderson, 1990). A benefit is the ease with which the tutor's behaviour can be modified without altering the production rules. This is allowing the development of a student-controlled version of LISPITS with variable granularity and feedback, which have been the major sources of student complaints. Subsequent empirical studies with the modified version where students have control of feedback time have seen a 50% increase in exercise completion times. The fact that the tutorial aspect has shown little impact suggests that the immediate notification and correction of errors is the greatest strength of LISPITS even though it is also the source of most student complaints.

Model tracing is particularly useful in determining why a student has performed a particular step with regard to the overall pattern of the problem, the underlying reasons, and thus provide assistance or comment as required. The student model is not only a means of generating explanations but a representation of student knowledge acquisition. *Knowledge tracing* is the term used in this system for the process of tracking student knowledge and providing remediation, and is the implementation of a mastery based system of learning. The tutor tests the student's knowledge on a particular rule through direct questions and inferences from situations where the rule is used in the solution of a problem, and if the student is correct 95% of the time, the student is said to have mastered the rule.

Evaluation studies have shown LISPITS to be effective: Students completed exercises 30% faster with 43% better scores on testing (Corbett and Anderson, 1992, p.83). As students use the tutor, it creates a file of student responses and the rule which governs the response, together with the time, in a three variable coding of Belief, Rules and Time. The tutor predicts the steps that the student might take in solving the problem, and with a known set of misconceptions it models student errors at each step. As long as the tutor can recognise the errors, it allows the student to progress, otherwise it provides an answer to that stage in the problem. At any time the student may also ask for hints or ask what to do next. One of the essential assumptions in the model is that problem-solving is hierarchical, with the goal being the final point at which all possible routes to the answer coalesce. One important *tutoring principle* is that the goal structure is explicit in the model, each branch which the student takes which may lead to the goal satisfies a unique subgoal.

AN ALGEBRA WORD PROBLEM ITS

Singley and fellow researchers describe an intelligent tutor built to help students in a first year algebra course solve a difficult part of algebra, namely "word problems" (Singley *et al*, 1989). In these questions the algebraic information to be manipulated is found in sentence form. A simple example is: If 5 apples cost $2.75, find the cost of 7 apples. The tutor uses model tracing and is initially constructed by performing a *task analysis* of algebra word problem solving, which consists of two steps, the representation of the problem and the search for a solution. The trouble is that these two phases are almost independent and mistakes in the representation may lead to an incorrect solution. Singley's rationale for cognitive modelling is put succinctly and simply,

> The model tracing paradigm is based primarily on two premises: 1) the majority of learning that takes place in the acquisition of cognitive skill occurs during the solving of problems and not in the perusal of textbooks, and 2) one needs to have an accurate cognitive process model of the student solving problems if one wants to tutor the student effectively. The strength of the model tracing paradigm is that, when the student makes a mistake, the tutor can localize the problem to a single primitive action, which can be interpreted as a piece of a larger plan. (Singley *et al*, 1989, pp. 270-271)

MENTONIEZH

MENTONIEZH is an ITS in geometry which coaches and corrects during figure drawing and proof building. The method of *proof-tracking* (Py, 1989) used in student modelling is one of recognising the student's intentions, which is an important step in personalising tutor/student interactions. Recognising the student's intentions in a proof involves *plan recognition* and provides the system with a criteria for deciding what assistance should be given, or if the system should intervene as the student attempts a futile or erroneous route to the solution. The first part of the system involves the student creating the diagram from the information supplied. A correct diagram is taken to mean that the student understands the hypothesis of the question. The proof tutor uses a static domain model, a dynamic student model and a dynamic pedagogical model to detect errors and explain their source, to specify student progress and the student's plan of the proof, and to intervene and explain as required. The student model is updated as the tutor and the student interact, and significantly, the system contains data about the student's meta-knowledge (the strategies and heuristics the student uses). The goal of plan recognition is to infer the student's intention from the parts of the proof he/she has given. The method is to label each of these component parts of the proof and to compare the student's progress with a tree diagram of all possible routes to the solution. This system has been implemented in Prolog on a SUN work station. (see Py, 1989).

EMMA

Another mathematics ITS is EMMA, described by Quigley (1989). EMMA is a program designed to teach linear equations and implemented on computers found in schools. It consists of four linked expert systems: A mathematical reasoner, an intelligent diagnostic pretest, a student model and a component which controls the tutoring strategies. Quigley notes that most ITS's have been constructed on the basis of some learning theory, but argues that educationalists have been unable to postulate fundamental constructs in learning in general and of a mathematical concept in particular which can satisfactorily be interpreted into ITS design. The design criteria of EMMA is therefore primarily its usefulness as a computer tutor. An interesting point made by Quigley is that in order for the ITS to maintain an accurate representation of the student's current knowledge state, and to be able to identify student errors and provide assistance, it is necessary for the system to know how the student understands mathematical concepts. That is, the system needs to be cognitively faithful. Students often see mathematics as a series of algorithms to be applied in different situations, and frequently mistakes are the result of the use of the incorrect routine rather than incorrectly applying the correct algorithm. Students also invent their own "rules", chunking knowledge into procedures which may not be conceptually faithful to mathematics but which reliably produce the correct answer.

FEATURE-BASED MODELLING

Yet another variation of student modelling is attributed to Webb (1989) and is called feature-based modelling. Feature-based modelling (FBM) attempts to model student cognitive processes by "mapping contexts to actions". It is beyond the scope of this paper to provide a full account of FBM, but briefly it involves pre-testing to determine the student's knowledge of the elements in the domain and is not domain specific. It does not require error diagnosis, and is flexible in the presentation of the material. It is robust, and the student models are runnable. FBM is different from most other student modelling in that it does not produce a pre-determined and explicit model of the student's cognitive processes. Instead, FBM builds the model from inputs from the student and the outputs it produces. It takes into account the knowledge domain, the student responses and the examples and instances the student has examined in the course of the tutorial. The knowledge domain is represented by a *feature network* which contains the elements of knowledge (or features) and the relationships between them. In a feature network there is a criteria for accepting or rejecting a hypothesis about the knowledge state of the student, which circumvents the problem of constructing a cognitive model using only information the tutor gains from the student's performance. In the absence of confusion caused by the user interface, or what is termed *cognitive noise*, a FBM system could adopt the method of most ITS and accept a student model if all of the student's behaviour was consistent with the model. In a FBM a student model is accepted where the student satisfies a set performance rate (usually 80%). The principal form of analysis in FBM is *erroneous association*. Here, instance features to which the student responds incorrectly are tagged erroneous. For example, if the student always provides a certain type of incorrect answer at a given instance feature, there will be an erroneous association between the instance feature and the student's response, or *action feature*. A feature is mastered when a student correctly identifies both content and action features. FBM builds a model of the student as a set of relationships between task features and action features. Each association implies that when each of the task features are found in the task, the student will act in a manner described by a single action feature. The associations may be erroneous (student misconceptions) or ideal (student mastery). Student misconceptions are dealt with through a cognitive modeller which explains student behaviour by examining student actions. Simultaneous multiple errors are handled through separate erroneous associations. As the student gains new knowledge through interacting with the tutor, the student model is no longer a true representation of the student's current knowledge state. This is called *concept migration*. The system uses a technique of *data ageing* by using a time variable and an aging factor (for example: data=0.9*data) so that newer data is given a higher priority than older data. FBM has been implemented through DABIS (Domain-Analysis Based Instruction System), a system which includes a lesson on English word classes in use at LaTrobe University. FBM has subsequently been evaluated by Kuzmycz and Webb, (1992). They describe FBM, giving details of its ability to handle noise and multiple errors, and evaluate FBM used in single-digit subtraction. Their evaluation showed that about 50% of student errors were accurately predicted by the system, in contrast to a value of about 6% for random guessing.

CONCLUSION

Each of the ITS described in this paper have a different approach to cognitive modelling with some commonality that could be extrapolated to a set of 'best' or 'desirable' features of a model-tracing intelligent tutoring system, as well as establishing some important principles of cognitive modelling. These are:

1. The fact that much knowledge is procedural means an effective tutor will need model-tracing to check that the student is on a correct path to the solution, as well as checking input at the finest granularity. This may be achieved by plan recognition which infers student intentions.
2. That cognitive modelling enhances the ability of a computer tutor to personalise the dialogue by overcomingproblems associated withthe enormous number ofbranches required through more traditional programming and authoring techniques, and thus it increases student-computer interactivity.
3. That the design of an ITS is based upon a general theory of cognition implies a degree of domain independence, but some domain specific features and procedures are equally desirable as long as the ITS ultimately does a good job of teaching.
4. A diagnostic pretest is desirable to determine the student's current knowledge in the subject domain, and to begin tracking the student's acquisition of rules at an appropriate level.
5. The student model must be dynamic and continually updated through knowledge tracing, using techniques such as data ageing, and it should be more than a catalogue of bugs and misconceptions, but also contain information about student belief.
6. That student misconceptions or erroneous associations may be corrected through remedial tutoring where the system employs a number of teaching strategies appropriate to the nature of the content and the student's current knowledge.
7. The design of the student-computer interface should be one which minimises cognitive noise and be cognitively faithful, that is, solve the problems as the student naturally would. Particularly in the case of intelligent discovery tools these processes will ideally be transparent to the student user.

While it is generally accepted that one-to-one teaching can significantly improve a student's performance in a subject through individual instruction, the promise of computer-based tutors is that they will one day supply all the benefits of "personal" tutoring at a reasonable cost. That this is becoming possible in certain well-ordered and limited domains is clear. Anderson (1992) states that all of high school calculus can be taught using current tutoring systems. However, the development times suggested are in the order of one hundred hours for one hour of good ICAI. It may well be that the simplest task in the development cycle of student-modelling intelligent tutors will be evaluating their effectiveness. For some researchers, (Corbett & Anderson, 1990) the criteria is simple enough: time to complete the lessons and score in the final quiz.

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ENHANCING THINKING SKILLS IN COMPUTER SUPPORTED CONTEXTS

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One of the most important challenges facing educators in the 1990s is how best enhance children's thinking skills. Growing largely from concerns that many students function poorly when it comes to applying complex thinking across the curriculum the need for teaching thinking is high on the policy agenda for Australian schools.

TOOLS FOR THINKING

Traditionally, the technological tools to support thinking and problem solving have been handed from one generation to the next. Until the introduction of computers, these tools have been items such as the abacus, pencils and paper, calculators, and slide rules. With the widespread introduction of computers, new materials such as word processing programs, data bases and spreadsheets joined the those traditionally used to provide cognitive supports for thinking and problem-solving. More recently, newer multimedia technologies allowing sophisticated visual and audio representations have enabled manipulation of environments and events to afford multiple perspectives on complex phenomena not readily available elsewhere. Spiro and Jehng (1990) believe that such representations may the building of flexible knowledge assembly and construction processes in complex domains.

The reality is, however, that sophisticated multimedia technologies do not yet exist in most classrooms. More commonly, there exists a range of stand alone or networked computers of modest capability. The question to be addressed then, is how best to harness this available technology to encourage the development of thinking and problem-solving skills that will serve children most effectively, both now and in the future?

TEACHING ABOUT THINKING

While some of the most visible approaches to developing thinking skills are those that "teach thinking" in isolation via a special program (for example the deBono "lateral thinking" program), a more viable approach is one that considers thinking within specific problems embedded in existing curriculum areas. According to this "infusion" approach, as thinking occurs within specific content areas or disciplines (Ennis, 1989) it should be taught in context. Unlike the packaged thinking skills approach, an infusion approach cannot simply be tacked on to the curriculum (Jones & Idol, 1990). It needs to be an integral part of the teaching-learning process throughout key learning areas. Essentially, this approach requires explicit attention to thinking skills that apply within the subject area. It also calls for strategic training for teachers in thinking skills development and an emphasis on their role as mediator, strategist, and collaborator in learning.

Notions that teachers should be facilitators of learning, rather than givers of knowledge, are not new and we can look back to curricula of the mid 20th century for similar suggestions about teachers' role in enhancing children's thinking and learning. More recently, though, we have gained new insights into the importance of mediating and scaffolding learning (Rogoff, 1990; Wertsch, 1991). Indeed, the social and cultural context of cognitive activity is now regarded as being central to intellectual development. It is generally accepted that learning occurs as children interact with adults and peers, and with materials. This interactivity both enables and reflects the coordination of thinking and action related to the definition and resolution of problems.

According to this view, the process of interaction and mediation of learning experiences provides ongoing stimulation and motivation, opportunities to negotiate and resolve cognitive conflicts, as well as support of a more metacognitive (or self-regulatory) nature. Initially, the interactive process facilitates social regulation and communication. Gradually, it develops into a cognitive function for self-regulation and thinking, and for the representation of knowledge. Engagement in these cognitive processes, which are generally manifested at an external level, results in the gradual internalisation of thinking skills for use in novel contexts. For young children, the use of language enables external processes to be displayed, shared, and practised (Vygotsky, 1978).

IMPLICATIONS FOR TEACHING

This perspective on intellectual development suggests a number of issues about relationships between social experiences, cognitive abilities and educational outcomes. In particular, it suggests that social context, especially participants' interactivity within the classroom, will act to mediate learners' cognitions as well as their perceptions of the goals and directions of intellectual activity. Equally important, is the way in which learners' cognitive and social experiences and perceptions influence interactional patterns with each other and with classroom tasks.

Creating environments in which to extend children's thinking, doesn't, therefore, require a complete overhaul of curricula. Rather, it involves processes of adapting existing resources and practices. And, it is by no means certain what works best in this respect. What is clear, though, is that teacher knowledge, support, skill, and commitment are central to planning environments that facilitate higher order thinking (LaFrenz & Friedman, 1989). Indeed, as the *Report of the Committee of Review of New South Wales Schools* (1989) emphasised, relationships between the students and the teachers must be at the centre of the learning process and the quality of performance by teachers is the fundamental determinant of the quality of education. In such a context educational technology can be considered as enriching the relationship between teacher and student and facilitating the delivery of quality education for all students" (p.260).

Essentially then, it is the teacher who must plan to scaffold children's thinking and learning through experiences and environments that require higher order thinking- that is thinking that is conceptually rich, coherently organised, and persistently exploratory (Lipman, 1991). The mere application of a particular combination of information technologies, no matter how sophisticated, will not improve students' thinking and problem-solving skills.

With careful planning though, computer-based learning environments even without sophisticated multimedia technologies, can afford the interactivity that generates cognitive supports or scaffolds to foster thinking skills. The individualised and interdependent nature of these supports, especially in relation to the monitoring and regulation of cognitive activity, seem instrumental in facilitating children's thinking and learning.

Within this "interactionist" framework the computer becomes both a vehicle for accessing and controlling information, and a tool to provide experiences which support and complement contemporary goals about the importance of thinking skills. In this sense, the technology can become the pivot for a new type of interactive exchange between learners and their environment (Pea, 1987). In some cases, the interactivity will be initiated by one child and the cognitive supports afforded within a computer program. In others, the interaction will be between more that one child, and perhaps a teacher or other adult, together with the computer generated activity.

EXAMPLES FROM TWO CLASSROOM CONTEXTS

Two projects with which I've recently been involved provide examples of interactive computer environments that are successful in affording a range of cognitive supports designed to facilitate students' thinking.

THE *WRITING PARTNER* PROJECT

In the first project we've used an "intelligent-like" tutoring system, the *Writing Partner*, to provide on-going metacognitive support to children during story writing (Elliott, 1992; Hicks, 1992; Salomon, 1992; Zellermayer, 1992; Zellermayer et al., 1991). Specifically, the *Writing Partner* guides learners through planning, monitoring, and evaluating story writing through a continuous prompting, guiding, modelling and cueing of higher order processes involved in text construction.

The major contribution of this computer-generated support is twofold: first it has the capacity to provide guidance through the entire writing process on an individual basis, a situation quite difficult, if not impossible, in a regular teaching environment; secondly, the task and content specific nature of the scaffolding act to generate an "intellectual partnership" enabling a learner to function at a level transcending the limitations of what could be accomplished alone (Pea, 1987; Salomon, 1990; Salomon, Perkins & Globerson, 1991). In this sense the computer, or more correctly the *Writing Partner*, acts as the more "collaborator" or "partner", by sharing and distributing the cognitive workload.

An on-going program of research using the *Writing Partner* (Elliott, 1992; Hicks, 1992; Salomon, 1992; Zellermayer, 1992) has shown that children's awareness of processes involved in good story writing, plus their actual story writing skills, can be improved through experiences with the tool. For example, in one study of low achieving year 7 writers there was substantial improvement in terms of overall story quality, plot, characterisation, mood, setting, dialogue, expression and mechanics. With more expert writers, I've noted improvements in use of linguistic features, such as lexical and grammatical intricacy, that contribute to plot organisation and overall narrative style (Elliott, 1992).

Importantly, there is evidence to suggest that *Writing Partner* experiences contribute to internalisation of strategies central to good story writing. For example, poor writers change their view of narrative composition as something that just "happens", with little sense of intentionality, planning or audience, to a cognisance of the need for planning, monitoring, reworking and revising, and the interdependent nature of these processes.

Most encouraging in this study, was evidence of students' ability to think more coherently about orchestration of writing processes within a narrative framework. They became increasingly aware of the need to manipulate content, plot, characters and causal structures, and of the metacognitive strategies necessary to effect interaction between story components.

Future developments for tools like the *Writing Partner* might include the meshing of text and graphic based metacognitive prompts with video images to create environments in which ideas can be accentuated to drive plot development. Imagine the power of a context affording ready access to a range of real life and real time audiovisuals, together with the scaffolds currently provided by the *Writing Partner* ?

THE EARLY CHILDHOOD MATHS PROJECT

In the second project a range of commonly available commercial software has been used as the basis for creating interactive experiences that support children's mathematical learning. As in the *Writing Partner* project, it was anticipated that the cognitive supports generated by the interactivity would act, in the Vygotskian sense, to mediate children's thinking in the cognitive space between what can be accomplished alone and in collaboration with more capable others. It was intended that this mediation process would provide ongoing stimulation and motivation for learning, as well as support of a more metacognitive, and particularly, self-regulatory nature.

In the mathematics context, self-regulatory mechanisms involved checking outcomes of problem-solving tasks, forward planning, revising strategies, and developing and testing new strategies. As with the story writing, the purpose of scaffolded activities was to help children plan, monitor and evaluate their activity, but this time in a mathematics context. Mathematics software used in the study was popular commercial material concerned with comparisons of shape, size and volume, ordering of events and objects, counting, one-to-one correspondence activities, representations of single sets, reproduction/comparison of sets, elementary arithmetical operations with sets, and a range of classification and sorting activities.

The mathematics environment required children to work in pairs, with a teacher. Here, the teacher took a much more active role as a mediator, collaborator and partner in the learning process than was the case in the writing context. Now, the teacher's role was to promote an awareness of the cognitive demands of the tasks and to guide activity within a purposeful and goal directed framework provided by the software. Rather than having to focus on the management and organisation of the learning experience itself, as is the case in more traditional mathematics environments, the teacher could focus on, for example, overall task orientation, and planning, monitoring and evaluating of cognitive activity. Sharing the "workload" with prestructured and sequenced computer-generated activities meant the teacher could concentrate children's thinking about their problem-solving- such as, clarifying and focusing on the topic, elaborating ideas, and reflecting on and evaluating decisions and responses. Additionally, complementary peer interaction, as well as the individual's own structuring of the activity, contributed to generation of the cognitive and metacognitive dialogues that supported and mirrored knowledge and thinking. In this sense the interrelatedness of the contextual supports lent themselves to framing aspects of self-regulated learning.

Results from the preschool investigations have shown that teacher mediated computer environments better assist children develop specific mathematics understandings than do more traditional mathematics experiences or those involving non-mediated computer activities. Importantly, they seem to encourage the beginnings of planful behaviours, such as goal setting, goal monitoring, self-monitoring and self-evaluating. Gradually, we would expect children to internalise the use of these self-regulatory strategies to enhance performance independent of the computer context.

CONCLUSIONS

Teaching students so that they become better thinkers is going to be a major educational goal for the remainder of this decade. Yet, as thinking inherently draws upon multiple knowledge bases across a range of curriculum domains there is no easy recipe for its teaching.

What is apparent though is that computer-supported learning environments offer a range of individualised yet interactive opportunities not previously available in classrooms. To be sure, such opportunities may be expensive to develop and implement, but they have cost benefit advantages if effective on a wide scale. Moreover, especially in the areas of mathematics and science, video and computer technologies enable the dynamic depiction of events and information not normally possible in the classroom.

Research with the *Writing Partner* and in computer-based, teacher mediated mathematical activities with preschoolers has suggested that cognitive and metacognitive supports generated by interactivity within these environments do indeed scaffold the development of thinking skills that manifest as improved outcomes in problem-solving situations.

Clearly, facilitating thinking does not necessarily require computer-supported environments that employ the most sophisticated technology. As seen from the examples cited above it is largely the cognitive supports inherent in the interactive nature of the contexts that create powerful learning environments. Regardless of the sophistication or otherwise of the technology, if we are to enhance children's repertoire of thinking strategies and skills, the teaching of thinking needs to be infused across the curriculum in ways that are planned, meaningful and authentic.

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TWELVE ISSUES TO CONSIDER FOR MANAGING AND SUPPORTING FUTURE TECHNOLOGY INITIATIVES IN SCHOOLS:

WHAT DID WE LEARN FROM THE QUEENSLAND SUNRISE CENTRE?

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This paper focuses on issues and implications for managing and supporting technology initiatives in schools. The central question addressed is - what have we learned from the Queensland Sunrise Centre (QSC) Project which might assist others involved in technology initiatives in schools? The twelve issues which emerged throughout a major evaluation study of the project are presented.

It is concluded that taking up the challenges presented by the new and emerging technologies is not an easy task. However, we believe that the educational rewards are potentially great for all who make conscious decisions to take up those challenges.

This paper provides suggestions and implications derived from the writers' experiences gained through their involvement in the Queensland Sunrise Centre (QSC) Project during its operation. In addition, the issues raised emerged throughout the conduct of an evaluation of the QSC (Finger, 1992).

The QSC Project was envisaged to be a major technological 'lighthouse' initiative to assist in "charting directions for the use of information technology in education" (Department of Education, Queensland, 1990). The QSC provided a technologically-rich environment for the students and teachers involved. Each of the students had the use of a personal computer for use at school and at home. Similarly, the teachers were given the use of powerful laptop computers for their own use. The classrooms of the QSC provided students with access to more powerful colour computers, CD-ROM units, scanners, modems, Keylink, printers, and a range of software programs with Logo as a central feature. At the commencement of the project, it was indicated that "Education will have much to learn from this innovative project" (Department of Education, Queensland, 1990). Three years later, we need to address the question - ***what have we learned from the QSC Project which might assist others involved in planning and implementing technological initiatives in schools?***

The following discussion addresses that question. Suggestions are made which might provide the basis for more informed decision making by those involved in managing and supporting technology initiatives in their schools. Most importantly, however, we suggest that the following discussion can assist in the search for solutions through the realisation that the context within which technology initiatives take place is a dynamic and human, educational setting. Indeed, this discussion is couched within a framework which "incorporates both the human and technical sides of technology" (Sachs, Russell, and Chataway, 1990, p. 50). In this way, the debate involves educators utilising a perspective within which the technical and human sides of technology can be synthesised to lead to the exploration of the connections between the new and emerging technologies and education.

THE NEED FOR REFLECTION

Although computers in classrooms have been a relatively recent phenomenon, there has been increasing interest, emphasis, and exploration of the use of computers in schools. Policies have been developed throughout the Australian States, conferences are regularly held, journals and texts specifically addressing educational computing have flourished, and school systems and their schools have been busily expending time, effort, and money to mount initiatives. Following this initial period of acquiring computers and exploring their potential, we strongly suggest that there is a need to step back and critically examine those early initiatives in order to learn from them. In this way, we can build on the successful strategies and avoid repeating the often very costly mistakes experienced by others. For example, as early as in the mid-1980's Higginson (1986, p. 21) suggested that:

> "In the early part of this decade, educational institutions found themselves in an exciting but unfamiliar position; the vanguard of social change. ... many educators were surprised to be thrown into wide-ranging and often heated discussions about the applications of information technology to their field. In the intervening years enough dust has settled... to permit a fairly clear view of the significant issues from the past to emerge, and informed speculation about priorities and directions for the future to be made."

More recently, Russell (1992), in providing a review of predictions for computers in education throughout the 1980's and indicating some of the issues emerging throughout the 1990's, observed that schools have been more concerned with "the acquisition of hardware and software than how it was to be used" (Russell, 1992, p. 154). He suggests that the accompanying

"lack of sustained discussion on the role of computers in thinking and learning meant that there was sometimes uncritical enthusiasm for computers in education" (Russell, 1992, p. 154).

He warns that:

> "Predicting the future based on the history of the past is a bold undertaking. ...In computer education, the hopes of the 1980s' often appear to have turned into disappointments. Some of the problems that beset us today were accurately predicted in the 1980s', but the warnings were largely unheeded." (Russell, 1992, p. 159)

Two implications emerge. Firstly, there is the implication that it is important that we reflect upon our QSC experiences and document what we have learned. However, that, by itself, is not enough if we are to ensure that 'the warnings are heeded' and that knowledge gained does not become knowledge lost. The documentation undertaken here needs to be complemented by the second implication that dissemination needs to be enhanced. We believe dissemination will provide an enriched platform of knowledge upon which further planning, implementation, and evaluation of learning technology initiatives can be built.

WHAT DID WE LEARN FROM THE QUEENSLAND SUNRISE CENTRE?

In responding to this question, the implications and issues are presented in a form which can be easily understood by the audiences it is designed to inform - system, regional and school administrators, educational advisers, computer co-ordinators, teachers, and personnel concerned with the pre-service and in-service education of teachers.

We have utilised the approach used by Mojkowski (1985, pp. 18-21) in the journal article "10 ESSENTIAL TRUTHS TO HELP YOU PLAN FOR TECHNOLOGY USE" to attempt to present the implications and issues in a clear, straight forward style. Mojkowski, who spent several years at the Merrimack Education Center (MEC) in Chelmsford, Massachusetts, worked with thousands of teachers and administrators ad-

TWELVE ISSUES TO CONSIDER WHEN PLANNING AND MANAGING TECHNOLOGY INITIATIVES

Twelve Issues To Consider

1. **Recognise the importance of people .**
2. **Develop an eductional rationale for the use of the new technology.**
3. **Build ownership of that rationale with the key participants.**
4. **Technology initiatives must be evaluated.**
5. **Introducing new technology into schools requires risk-taking .**
6. **Teachers require both training and professional development in the use of the new technology.**
7. **Examine carefully the budgetary considerations for the acquisition, repairs, and upgrading of equipment.**
8. **Establish appropriate access to technical, curriculum, funding and professional support.**
9. **New technology can assist in rethinking education.**
10. **New technology has implications for classroom organisation and management.**
11. **Computers are inherently subversive.**
12. **Slow travel ensures the quickest journey.**

Table 1

dressing the challenges of new technology. As a result of those experiences, he formulated ten essential 'truths' which he insisted must be addressed if we are to realise the potential of educational technology. The ten essential 'truths' to which he referred were that computers are tools, new technology is a catalyst for curriculum revitalisation, teachers and administrators need more and better training, microcomputers have their limitations, our definitions of computer literacy need clarity, computer education programs must be evaluated, most software is inadequate, technology is a catalyst for increased planning for school systems, technology will alter the organisation of schools, and computers are inherently subversive.

Following a reflective process of examining these issues proposed by Mojkowski together with discussions and analyses of our individual and collective experiences gained through our involvement in the QSC Project, we suggest twelve issues to consider. We believe that by considering these issues in terms of their own school and classroom contexts, others can maximise the effective planning and implementing of technology initiatives in their schools. Based upon our QSC Project experiences, we propose the following as shown in Table 1 on the previous page.

1. RECOGNISE THE IMPORTANCE OF PEOPLE.

This has been placed first to emphasise the importance of education being seen as a human endeavour. Teachers, students, parents, and administrators are people. This might seem obvious but at the heart of any plans, there needs to be a recognition of the importance of the people involved and the contributions they can make. Central to the project were the students and their educational growth. The success or failure of attempts at integrating learning technology in schools relies heavily upon the people involved in that process. The roles played by the students and their teachers are vitally important. Throughout the last three years, there has been some evidence that some hold the view that the injection of computers into classrooms equates with success for all students. There has also been evidence that others argue that computers in classrooms make life 'easier' for teachers. Our response is that these positions indicate a naive analysis of what happens in classrooms. The commitment, dedication, skills, and knowledge of the teacher are ultimately more important than the mere provision of resources whether those resources are reading materials, art materials, or computers. The teachers involved in the QSC Project worked long hours, were exposed to criticism, took risks, and made huge personal commitments to the project. As one of the teachers indicated in response to being asked what have been worthwhile outcomes resulting from involvement in the QSC Project:

"Personally - HUGE growth in 'technological' knowledge - interest in programming, rethinking teaching style, 'buzz' at being a player in an 'international' level of competition, willing to have a go at almost anything, much greater perseverance and raised frustration level, ability to see the positive outcomes of any situations - I don't regard ANYTHING I have done in the project, no matter how frustrating or time intensive, as a waste of time." (Year 8 QSC Teacher, May,1992)

"No good deed goes unpunished" was a statement made by the Project Officer to the teachers involved in the project in 1990 and has often been recalled by the teachers when they felt that things had become difficult. The saying highlights the observation that despite efforts having good intentions, there will often be someone ready to be critical. Undertaking significant initiatives can invite unwarranted criticism. Some evidence of that emerged. Teachers indicated the importance of support from administrators and their peers. Fortunately, that was provided through their operation within a very professional, supportive school setting. This was evident in comments submitted by several QSC Project teachers in referring to their administrators as sources of support:

"Interest and enthusiasm in all aspects of the project. Participated in workshops and ran inservice where possible. Fought for all initiatives and supported teachers at all stages. Met with Project Officer on weekly basis in 1991 to plan strategically. Also worked to familiarise parents with the project at all times." (QSC Teacher, May, 1992)

"Professional and moral support." (QSC Teacher,May, 1992)

"Helped with parent meetings and most workshops. Maintained strong ultimate school responsibility for the project. Represented the project at Regional Office and Central Office meetings." (QSC Teacher, May, 1992)

We need to value people. We must break the cycle, referred to by Doyle and Ponder (1978, p. 1) which reacts to discrepancies between promise and achievement by a "redoubled search for procedural solutions". Rather, we need to base more effective change strategies on "a more thorough understanding of the naturally existing mechanisms which operate in school environments" (Doyle and Ponder, 1978, p.1).

2. DEVELOP AN EDUCATIONAL RATIONALE FOR THE USE OF THE NEW TECHNOLOGY.

This has been placed second on this list due to its importance in drawing attention to the educational questions which should provide a starting point for integrating learning technology into schools. In many situations, it appears that the hardware and software is purchased before the educational rationale has been developed which we believe is a technocentric approach rather than an educational approach.

The search for an educational rationale for a technology, which has been spawned by the space race, nurtured by the international munitions industry, and utilised by the business industry to cut both costs and jobs, has been long and tedious. In the last ten years, education has moved from being on the brink of a major revolution in the ways of learning "based upon the technology of the digital computer" (Bork, 1981) to an appreciation that to be of value to education the computer must be seen as a tool, akin to, but far more interactively 'intelligent' than the pencil, the microscope and the book which are well integrated into daily learning activities (Salmon, 1990). Three rationales for using computers within the education have been tentatively posited by Grimmett (1992):-

- as a personal ***amplifier*** to enhance the productivity of the learner;
- as an educational ***actualiser*** to extend and enrich the school based experience of learners; and
- as an ***intellectual tool*** to empower the learner.

Of these three rationales the most intractable but possibly the most powerful has been that of using technology as an intellectual tool. It was intractable for many reasons not the least being that until the Queensland Sunrise Project was initiated, few educational environments existed with sufficient computers to allow the viability of the intellectual model to be explored. Through the establishment and sustained operation of the QSC, this rationale has been explored and found to be viable. Students and teachers in the QSC Project have used computers as intellectual tools by allowing for the development of knowledge through interaction with the media and the customising of the manner in which the media functions so that it better facilitates the construction of knowledge. Given that learning episodes using computers as intellectual tools can be continued at a later date does not require continual access to the media to enable continued functionality for the learner.

The development of an educational rationale is important and that rationale might be developed by examining the planned educational purpose of the technology in terms of being an *amplifier, intellectual tool*, or an *actualiser* or some combination of these. The QSC Project has demonstrated that there exists strong potential for computers to be used by students as *intellectual tools*. Furthermore, we suggest that it offers an approach through which we can promote "effective teaching and learning to be undertaken with levels of resourcing that are less than continual saturation, thus it has immediate utility within present classrooms" (Grimmett, 1992, p.6).

3. BUILD OWNERSHIP OF THAT RATIONALE WITH THE KEY PARTICIPANTS.

Independent of the rationale that underpins the introduction of computers into the school, it is most important that the rationale is embraced by those directly involved in its implementation. In examining successful learning collectivities in relation to teacher development programs, Logan and Sachs (1991, p.307) reported the following features to be characteristics of collegial groups: participants believed in the importance of the task they were working on, members had sufficient time to get to know each other and to build trust and respect, leadership was sensitive and authoritative, groups were small, involvement gave some immediate rewards and benefits, and a spirit of inquiry and assistance prevailed (Logan and Sachs, 1987). These aspects were largely evident in the QSC approach and experience.

Within the QSC a number of strategies were used to ensure that major stakeholders had ownership of the innovation and its rationale. These strategies included:-

- Project teachers were involved in the negotiation, development and writing of project policy documents;
- Regular meetings of project, school and regional personnel who have responsibility for the innovation;
- Preparation (by project stake holders) of papers, presentations and workshops; for on-site delivery or incorporation in state or national conferences; and
- Cooperative budget planning.

As change can only enter classrooms through teachers, it is imperative that teachers be provided with the opportunity to vary their professional behaviour in such a way that they can facilitate the adoption of changes in educational practice afforded through the use of technology for learning and required by the rationale developed by the school.

Any rationale must be owned and reflected in the actions of all participants if the rationale is to lead to altered professional behaviours which allow new activities to be infused into the classroom experience of students. Teachers, through their professional activities, create a classroom climate which to a large extent defines acceptable student behaviours. In short, it is the teachers who first must adopt a new rationale if changes in classroom culture are to occur.

This, to a large extent, was achieved within the QSC through including teachers in the process of developing the project itself. It was the project teaching team which after reading, review, and reflection produced a working philosophy for the project which:-

- established convictions regarding directions and initiatives being undertaken by the project. That is, it redefined the rationale in operational terms for the teachers;
- provided a means of checking consistency of actions and policies;
- provided a framework against which evaluation could be constructed; and
- aided communication with other educators so that they could understand the underlying concepts of the QSC Project.

This teacher developed philosophy provided a basis upon which an understanding of the project rationale could be developed with other significant partners in the enterprise.

4. TECHNOLOGY INITIATIVES MUST BE EVALUATED

There has been a lack of comprehensive evaluation studies of technology initiatives in schools. Evaluation needs to be planned as an integral part of the program planning and management. Teachers, students, and administrators need to be able to evaluate how effective programs have been in order to enhance further program decisions. For example, did the program contribute to more effective learning and teaching? Were there detrimental effects? Could the program have been managed more efficiently and effectively? In essence, evaluation should be undertaken to provide information about what we have learned in order to inform our planning through the revision of our current programs. We suggest that schools could strategically address this through making links between *school computer policies and programs, school development plans*, and *collaborative school reviews*.

We have witnessed the formulation of plans for technology initiatives, which have been followed by implementation in schools, and then new initiatives are mounted before there have been any comprehensive evaluation of the previous initiatives. The QSC deviated from that process as the planning included a research model. After three years of operation, the QSC Project has been the site of three significant research reports (Ryan, 1991; Finger, 1992; and Rowe, 1993).

The evaluation study (Finger, 1992) reported the insights, impact, and issues which can be gleaned from a major 'lighthouse' initiative. In addition, it formulated a model for guiding the study which might be used as a basis for evaluating further technology initiatives in schools. The model developed utilised an adaptation of the Stake-Batchler Model (Thorne, 1990) and drew upon Owen's (1992) evaluation Forms. Owen suggested that it is an important first step to identify the design of the evaluation which is appropriate for the program being evaluated. Five evaluation Forms were proposed by Owen: - *evaluation for development, design evaluation, process evaluation, monitoring evaluation,* and *impact evaluation*. An appropriate evaluation approach can be chosen from any individual or combination of Forms according to the program's *orientation, state, focus,* and *timing*. This helps in establishing links between the educational rationale for the learning technology initiative and the evaluation of that initiative. Moreover, the model used to guide the evaluation drew upon the evaluation literature and, in particular, *fourth generation* evaluation models which emphasise the need to identify, negotiate with and involve the key people in the evaluation process. *Collaborative School Reviews* provide a tangible opportunity for this approach.

5. INTRODUCING NEW TECHNOLOGY INTO SCHOOLS REQUIRES RISK-TAKING.

Schools are exceedingly complex organisations within which the educative process is undertaken using a great variety of strategies, resources, personnel and special skills. The introduction of technology for learning into the school culture requires more than simply purchasing technological resources and expecting that teachers will use them in some meaningful way in their classroom activities. This strategy has been tried in the past with other technologies and met with failure.

> "All the language laboratories and teaching machines are gone. Not one of them can be found anywhere in the United States right now."
>
> (Snyder, 1988)

To enable technology for learning to become a valuable and integral part of a school's learning resources requires some restructuring of the school milieu. It requires teachers, administrators, students and parents to take risks and reject proven strategies and attempt untried methods which utilise computers as indispensable learning tools. In spite of the natural and responsible conservatism which exists within schools, teachers and administrators are willing to take risks provided that they are informed about the goals of the innovation, the benefits to themselves and other members of the school community, and the risks inherent in the innovation.

The teachers and administrators involved in the QSC Project worked within a high risk, innovative investigation. One of the outcomes of the QSC experience has been that the process of introducing technology into classrooms requires teachers and others to take risks. In such a high risk environment, higher than normal levels of support were necessary. This included an extra teacher assigned to the QSC classes and the appointment of a Project Officer. The Project Officer was engaged in a wide range of management duties and played a vital role in maintaining interest and effort among the teachers involved.

6. TEACHERS REQUIRE BOTH TRAINING AND PROFESSIONAL DEVELOPMENT IN THE USE OF THE NEW TECHNOLOGY.

Teacher competence in operating the computer is a necessary but insufficient precondition for the computer to become a viable resource within the classroom. The provision of both professional development and training is essential if a rationale based upon the use of technology as an educational resource is to be actualised. Through the operation of the QSC, it became obvious that it is necessary to separate out the *training* (required to make teachers competent users of the technology) and *professional development* which is necessary for teachers to successfully incorporate the technology into the classroom experience of their pupils. This was done because training and professional development are two separate functions which need to be considered separately if each is to be successfully undertaken.

An additional reason for separating out training and professional development is that they should not be undertaken together initially. Teachers need time to meet all of the problems involved in the use of technological tools (e.g. copying files, adding graphics, crashing disks, losing files, controlling printers etc.) prior to facing the avalanche of problems which can result from introducing a number of computers into a classroom of students. Traditionally, professional development has often been treated as a formal course (e.g.

E.L.I.C., F.L.I.P.) within a strict time frame. However, professional development can be undertaken gradually using informal collegial networks. Through this technique, costs are reduced and teacher readiness can be monitored, thus reducing wasteful effort.

The advantages of deferring professional development until teachers have become comfortable with using computers are threefold; viz.

- cost is reduced;
- the natural enthusiasm which accompanies computer competence can be used to power the introduction of computers into the classroom; and
- the professional development program rapidly becomes self-generating.

7. EXAMINE CAREFULLY THE BUDGETARY CONSIDERATIONS FOR THE ACQUISITION, REPAIRS, AND UPGRADING OF EQUIPMENT.

The cost of maintaining the QSC equipment over the life of the project has brought into stark contrast the need to plan effectively for all of the costs (including maintenance and replacement) associated with the provision of classroom technology. Ideally, this would be a five year plan developed prior to the commitment of school funds. The QSC experience has been that at least twenty percent of machines will require repair during a school year and that each repair will cost approximately $400 - $500. Indeed, at the end of the first year of the QSC Project in 1990, approximately fifty out of sixty laptop computers required keyboards to be either repaired or replaced. When questioned whether or not this level of repairs was the result of problems with the product, Toshiba representatives indicated that the failure rates of laptops at sites other than the QSC was approximately 1-5% of machines. They suggested that there was a need to stress care of the machines by the children. While the effective life of classroom computers might be extended by constant maintenance, care and repair, realistically five years seems to represent their economic life.

Digital technology is acknowledged within Australian Taxation Law as having a very short useful life. Alternatives to outright purchase exist for schools wishing to provide their students with access to information technology. These include lease and buy-back agreements. The cost effectiveness of these alternatives is yet to be determined as is the efficiency of purchasing extended warranties or maintenance contracts.

In 1991, the QSC budget allocation for repair represented 15% of the total hardware budget and this was increased in absolute terms in 1992 to 20% as none of the machines in use in the project were covered by the manufacturer's warranty.

8. ESTABLISH APPROPRIATE ACCESS TO TECHNICAL, CURRICULUM, FUNDING AND PROFESSIONAL SUPPORT.

At the commencement of the QSC it was thought that providing the technology and allowing teachers and students to learn about it together would prove to be an effective strategy for introducing technology into the classroom. After a very short period of time early in the QSC Project, it became obvious that teachers needed access to a range of support services for the technology was, of itself, not an educational resource.

"Children do not learn from good hardware, software or courseware; they learn from goal-directed intellectual activities that good software affords and invites and that good teachers encourage." (Sheingold, 1987)

As a group, while teachers are gradually becoming more interested in the new technologies, they have shown an enduring interest in providing the very best learning experiences for their students. Thus, it is desirable that teachers see technology as a way of enhancing the quality of education. The provision of support services facilitates this process and allows teachers to begin integrating learning technology into the classroom culture without having to develop a deep understanding of the technology past the user level. Without the existence of support services, adequate funding, and resourcing, learning technology can rapidly become just another imposition on teachers or a subject to teach rather than a catalyst for improving the teaching-learning process.

9. NEW TECHNOLOGY CAN ASSIST IN RETHINKING EDUCATION.

It is now becoming obvious that information technology which includes personal computers, modems, CD-ROM disk drives, digital scanners and a vast range of software can potentially assist in the restructuring of schools and the educative process itself. There is evidence of *economic, pedagogic* and *sociological* factors (Cerych, 1985, p.225) operating for the introduction of technology into schools. The primary motive for the establishment of the QSC was from a *pedagogic* orientation. However, many students and parents were found to assess the utility of involvement in the project from the perspective of *economic advantage* through improved career and employment prospects. *Sociological pressure* for using technology within classrooms has emerged both in the QSC and in the wider educational scene. Parents of students in the QSC Project were found to have a largely deterministic view in which they saw a 'technological future' as being inevitable. Evidence of sociological pressure in the wider educational setting can be gauged by the number of parents who are enrolling their children in schools where every student is required to own her or his own personal computer and the almost exponential growth of the number of schools which are responding to those forces.

Sachs, Russell, and Chataway (1990, p. 53) identify three main perspectives of technology. Firstly, there is the perspective that technology is linear and deterministic in that society must adapt. The second perspective assumes that technology is dependent on society. The third perspective rejects both the first and second perspectives and it accommodates:

"the process of evolution and continual selection from a spectrum of technological alternatives; the selecting creates tension and leads to opportunities for exploring and experimenting with institutional and organising forms and actions." (Sachs, Russell, and Chataway, 1990, p. 53)

We suggest an ongoing examination of the issues which technology presents for rethinking education will most appropriately be addressed from within this third 'technochoice' perspective (Sachs, Russell, and Chataway, 1990, p. 53) in which a 'middle-ground' is assumed between the first two perspectives. For example, experience gained from the QSC indicates that working within technology-rich classroom environments, teachers have investigated not only how the technology might facilitate more effective teaching and learning within the context of the present curriculum, but also they have begun to explore the implications for changing the curriculum. That is, choices have been made by teachers from within a framework of possible technological and educational options. Pedagogic changes have occurred in the form of more collaborative, cooperative learning. There has been evidence of shifts in the control of power and the distribution of knowledge from the teachers as the sole authority and controller of the selection and pacing of knowledge to a more shared, investigative teaching and learning environment in which the computers have been used as *intellectual tools*.

10. NEW TECHNOLOGY HAS IMPLICATIONS FOR CLASSROOM ORGANISATION AND MANAGEMENT.

A single computer in a classroom can be the cause of a great deal of disruption to the smooth functioning of classroom activities through printer noise, and teacher or student distraction. The challenges associated with organising classrooms so that technology can be effectively managed can be expected as technology becomes more common in classrooms.

A number of successful strategies have been utilised within the QSC and these are included as starting points rather than definitive solutions.

- Students were selected to become class experts for a particular piece of software or hardware. These children were accessed by other students as and when required.
- Shared technology resources (scanners, modem, printers etc.) were placed where they were visible from most points in the classroom. This ensured that those waiting to use a resource could continue with another task while they waited for 'their turn'.
- A system of booking time to use the CD-Rom and Scanner was initiated to ensure equitable access.
- Copying files from disk to disk was undertaken cooperativelyby students rather than by the teacher.
- Students were responsible for managing their own disks and making backups of their data files.
- Significant blocks of time were allocated to group work. This ensured that the students could work uninterrupted on individual tasks for significant periods of time.

11. COMPUTERS ARE INHERENTLY SUBVERSIVE.

Within the QSC it was not uncommon for the teacher to have a technological problem or process explained to her/him by an eleven or twelve year old student. This could certainly be seen as a subversive role reversal and gives a new meaning to the adage "By his pupils he is taught". As students interact with a personal intellectual technological tool, they repeatedly set their own tasks, develop curricula which they hope will enable them to successfully complete their task, evaluate their progress towards their goal and restructure their work program. This process is at the heart of the subversiveness of technology. At the commencement of the QSC Project, considerable discussion among teachers and those involved in steering the project considered the possibility that, as students might be able to undertake and complete their work more efficiently and more independently through access to personal computers, it would be possible to remove teachers from education altogether. However, the QSC experience has been that the further students progressed, the more they required skilled teachers. In addition, it was observed that the students need teachers to 'teach' them in different ways.

The QSC has reflected the need to be aware of the existence of the hidden curriculum and restructure it. Students working independently upon self selected tasks and projects need the teacher to actively facilitate the learning process through providing them with:-

- knowledge of resources and how they can be accessed,
- a range of problem solving strategies, and
- ways of developing prerequisite skills.

No longer is the teacher seen as the definitive authority, the purveyor of knowledge and the evaluator who determines the worth of each pupil's efforts and yet this is the usual role demanded of the teacher by the hidden curriculum within schools. The QSC has indicated the subversiveness of technology for through this project it has become obvious that technology can enable changes in the relationship between teachers and students to take place.

12. SLOW TRAVEL ENSURES THE QUICKEST JOURNEY

The process of bringing computers into the educational landscape and changing the landscape to enable computers to positively affect the quality of education will be slow. Bork (1981) indicated that he believed it would take twenty-five years and at present we have possibly another fifteen years before we can expect widespread, fundamental changes to be achieved. Change at the system and school level need to occur but, more importantly, the familiarity of teachers with the technology needs to be developed. Changes in classroom practice within the QSC occurred after the teachers themselves became competent users of the technology and this might possibly be the first step in the journey of the technology from the space race to the classroom. Once teachers have started using computers as personal tools to assist them outside the classroom, a great deal will have been achieved and the classroom/educational issues discussed in this paper can then be considered by practitioners who have more realistic expectations. To attempt wholesale change in education today is to court disaster for the QSC represented an important but small step in developing an appreciation of the contribution that computers can play in education.

CONCLUSION

From our experiences through being involved in the QSC, we firmly believe that benefits are to be had through the use of the new and emerging technologies for promoting effective learning and teaching in schools. For teachers, computers can be used to enhance their lesson planning, assessment, preparation of documents, as well as enhancing students' learning experiences. The new technologies are revolutionising the management of the vast amount of information which can be collected, accessed, disseminated, and acted upon. In this paper, teachers and administrators have been provided with cautions and suggestions to assist them in managing and supporting learning technology initiatives in their schools through the presentation of twelve essential 'truths'.

We have argued that it is not merely technological issues which must be addressed. It is important that all who are involved in technology initiatives need to recognise the importance of people and the vital roles played by individuals. Furthermore, we suggested that the early development of an educational rationale for the use of the new technology is critical early, and that it should occur through a process which promotes ownership of that rationale by the key participants. Moreover, planning needs to include evaluation as an integral part of the initiative. The introduction of new technology into schools requires risk-taking, and teachers require both training and professional development in the use of the new technology. The program of acquisition of hardware and software should follow and complement rather than precede the development of the educational rationale. Funding represents an ongoing and expensive concern and schools are urged to consider carefully the budgetary considerations for the acquisition, repairs, and upgrading of equipment. It was identified that teachers require access to technical, curriculum, and professional support. Further 'truths' related to the proposition that new technology can assist in rethinking education, has implications for classroom organisation and management, and that computers are inherently subversive. Finally, we suggested that perhaps slow travel might ensure the quickest journey for schools in their efforts to integrate learning technology.

What is clear is that taking up the challenges presented by the new and emerging technologies is not an easy task. However, we believe that the educational rewards are potentially great for all who make conscious personal and professional decisions to take up those challenges.

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USING MULTIMEDIA IN LAW LECTURES

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This demonstration will explore the use of multimedia as an enhancement to law lectures at University level. Computer-assisted presentations can be divided into four categories - those which make use of: (1) text; (2) line art and animation; (3) sound; and (4) photographs and videos. It will be suggested that each of these media types have their place; and that mastering them forms a natural progression so that they can be learnt and used incrementally.

The demonstration will include examples typifying how each can be used in teaching law, as well as brief explanations of how the examples were created using Microsoft PowerPoint, MacroMind Director, Adobe Photoshop, Adobe Premiere, and SoundEdit Pro on a Macintosh.

INTRODUCTION

Most University lecturers can use an overhead projector. Some are beginning to use computer software to generate and present overhead slide shows. Will lecturers soon be expected to go one step further and use multimedia presentations in lectures? It will be suggested that this expectation is not only unavoidable, but highly desirable.

The focus of this demonstration/paper will be on how easy it is to create a multimedia presentation, and how the skills needed can be learnt gradually over a period of time. The skills will be taken in four steps: using (1) text, (2) simple line art and animation, (3) sound, and (4) photographs and videos. Taken in the order mentioned, it will be shown how each of these categories build on the skills already learned in using the media in the previous category. This means that there is a natural progression or path through the maze of skills needed.

Although the examples will show how a multimedia presentation can supplement lectures in law at a University level, the skills, techniques and ideas demonstrated will be equally useful in any environment in which a presentation is to be given to a number of listeners.

It will be assumed that there is no need to investigate a definition of "multimedia" - media in this sense merely means an agency of communication. Although they might not be the ideal method of instruction, it will also be assumed that formal lectures at University level will be a necessary part of teaching for many years to come. It is therefore necessary to make lectures as enjoyable and as effective as possible. Using multimedia is merely one response to this need - although it ought not to be the only response.

USING TEXT

Most lecturers these days have their lecture notes prepared in word processable form (machine readable). The first and most obvious point to be made here is that it is very quick and easy to copy this text into a presentation program. A little massaging the text into shape will enable very effective slide shows. The advantages of this form of presentation compared with overhead projector transparencies are as follows:

- it is easy to add bright colours and bring vibrancy to your audio-visual aids
- the text can be changed quickly and easily
- it is no longer necessary to hide the transparency and then uncover each point as the presentation develops - you can add to a composite slide as you begin talking about a new point
- it is easy to use a different text colour to highlight or emphasise any particular point

A few tips might also be appropriate. You will need to check that the equipment works properly. There is nothing worse than the embarrassment caused when equipment fails - and it has a habit of failing frequently unless the most scrupulous checks are done. Apart from checking that the text is large enough to be seen from the back, you will also need to confirm that the colours you use can be seen clearly in the delivery venue. Colours have a horrible habit of appearing differently in different venues!

Using a graphics presentation program is very easy. We will demonstrate how one can create a typical text slide like the one below (but in colour) within a few minutes using Microsoft PowerPoint.

USING SIMPLE GRAPHICS AND ANIMATION

(a) Simple graphics

Simple graphics or line art can be drawn or imported. If imported it is often known as clip art, although this term includes other graphics such as scanned photographs.

Drawing your own simple line art is easy enough using a graphics presentation program. For example when discussing a legal case or a hypothetical example where someone has done something, one can depict the persons graphically, even if it is only a stick person. Your presentation software will usually have simple drawing tools, such as squares, rectangles, ovals, and circles. You can depict movement or the passage of time with lines or arrows.

Importing clip art is equally easy, once you are set up to do it. You need a source of clip art first. You will also need time to browse through it (or an efficient indexing system) so you know what is available when you are looking for something. With most programs operating in a graphical environment, (such as Macintosh and Windows), you should be able to copy the item you want and paste it where you want.

(b) Animation

So far we have built screen presentations with text and simple graphics. These are relatively easy to create. But being static, they can be a little boring. It would be nice to have some movement.

Until recently, no graphics presentation program (that we were aware of) was able to produce animation. We understand that there are now some software programs capable of doing this. Unfortunately we have not been able to try any of them yet. We turned to MacroMind Director (which has always been regarded as more than just a graphics presentation program). It is a very powerful piece of software - capable of much more than animation. Many sophisticated interactive presentations including video and sound have been created with this program. At this stage of our learning curve, we have only scratched the surface.

MacroMind Director has two facilities - Overview and Studio. At a very basic level, both enable you to take items such as text or graphics which you have created with other programs, and set up a sequence for them to be displayed on the screen. Overview is the simpler facility. It has no drawing tools or features for editing images which you have chosen to use. It does have the ability to animate text (eg scroll onto the screen), and use different transitions (such as wipes and fades) from one screen to the next. We will demonstrate a few of the more useful features.

Studio on the other hand is far more complex. It has greater control over each frame including the ability to manipulate each one of several items on the "stage" during a particular frame. It can handle two separate sound tracks, as well as several video clips, and is rich with features for transitions and animation. We will demonstrate at a simple level the way in which Studio can be used to create an animated presentation.

USING SOUND

It is amazing what a difference a sound track makes. The use of sound really brings a presentation alive. One obvious tip - you need a library of sound effects on which no royalties are payable!

We will demonstrate the difference between a presentation without and one with a soundtrack. We will also show how easy it is to edit and add sound to a presentation using a program like SoundEdit Pro.

USING PHOTOGRAPHS AND VIDEO

The last part of the demonstration will show how easy it is to include photographs and video clips in a presentation. We will briefly show how one can use tools like Adobe Photoshop to capture and touch up photographs; likewise the use of Adobe Premiere to edit video clips; and how both types of image can be incorporated into a MacroMind Director presentation.

HYPERMEDIA TECHNOLOGY AS A CROSS CURRICULUM TEACHER TOOL

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So-called "authoring" systems have existed for many years, supposedly to allow teachers to produce meaningful software to support their teaching program, without actually having to become programmers. Until the advent of the "hypermedia" group of programs such authoring tools saw little popularity.

Today the classroom teacher has access to a wide range of hypermedia authoring tools which require no programming skills beyond the use of the computer itself. How do these programs work, and are they as truly versatile as potential users may be led to believe?

This paper looks briefly at the history of hypermedia tools, some of the research into their effectiveness, and examines one model in detail, demonstrating examples of its use across a number of curriculum areas.

The paper also opens discussion on the need to develop a style of presentation of hypermedia planning, as traditional flowcharting techniques used by conventional programmers fall short of the potential of hypermedia planning.

THE HISTORY

Hypermedia as a concept can be traced back in fiction to the pulp science fiction magazines of the 1940-1950 decades. It was common for the protagonists to use hand held sound/vision/text/retrieval devices, often ones which doubled as a communications device. The important point to consider here is that this period was mostly BEFORE the advent of the computer, and definitely before the professional world considered the computer to be a tool for the masses (Aldis, 1964)

Essentially, the human concept of what a computer could be asked to do, in terms of how it presented information, was years ahead of the computer masters ideas, and decades ahead of the technology itself.

By the 1960s some computer users, such as Sutherland (1965) were beginning to think that the computer could be more interactive, while developers outside the computer sphere were looking towards multimedia tools for training (Rheingold, 1991). Aircraft simulators, for example, tried to present the user with a visual/ kinetic/sound version of what was happening, while realistic controls caused real-time effects on the simulation. It was quite clear to these occupational trainers that reality based training was more effective than other forms which isolated the student from the activity, or which limited the sensory impact of the session.

One early attempt to produce an interface between the author and the computer was PILOT, which worked on 8-bit machines and appeared on various platforms. Although specifically intended to take the drudgery out of programming the weakness of PILOT was that the user still had to learn a large range of code-specific instructions, for example, prefacing with a code letter and colon- G: FirstPicture; S: this is a statement; and so on.

With the advent of powerful microcomputer technology the ability to both simplify the interface and increase the response rate of the equipment meant that singular use of a keyboard or other delayed reaction interface was not necessary. Users could respond almost as quickly as the thought was formed, and the computer could do likewise. Mice, tracker-balls, touch-screens and light-pens added a new meaning to the term "user interface".

Around 1985 Apple started bundling a program called "Hypercard" with their Macintosh computer. Hypercard was a new concept in user controlled software, because it allowed the user to create "stacks", or individual screens, of information which could be linked in a variety of ways defined by the user. A Hypercard stack was very easy to create, with so few instructions necessary that pre-school and infants children could quickly master the ability (Chopping, 1989).

Hypercard opened the way for a huge amount of material to be quickly created by educators who had been frustrated by either their own limitations as programmers, or the lack of true educational value in material prepared by 'real' programmers.

Since the original release of Hypercard many things have happened, in particular the adoption of the style to other computer platforms, notably MS-DOS and RISCOS, as well as a reversal of the earlier Apple policy of supplying Hypercard free. Apple now appears to have a policy of supplying only a limited version of Hypercard, and of charging for it. This has implications for the dissemination of hypermedia materials on all platforms.

Effectiveness of Hypermedia Systems
There is very little research in this area to draw from.

Blackstock & Miller (1992) examined how childrens' symbol manipulation was affected using hypermedia as well as other edge technologies, compared with traditional systems. In 1991 the Council for Exceptional Children (Washington) produced the Trainer's Resource Guide, which included a section for teachers on the design and evavuation of authoring courses, DTP, hypermedia, and interactive videodisc. This was actually a comprehensive work which is unfortunately hard to come by.

Figure 1 attempts to display a hypermedia stack diagrammatically. The main components of a screen are shown, as are the links between that screen and others in the stack.

Also in 1991 McBride & Wilson produced a monograph on the Multimedia Technology Seminar held in Wahington that year. Papers presented dealt with, among other items, the role of learning theory in the development and application of multimedia technologies in special education. Indeed, throughout 1991 Special Education seems to have been a focus of activity in hypermedia design in the U.S.

James Spector (1992) with others presented a paper innocently entitled "Intelligent Frameworks for Instructional Design" to the Annual Conference of the American Educational Research Association in April, 1992. It will be interesting, to say the least, to see what comes of this work, as it deals with the use of Artificial Intelligence to assist designers who lack expertise in the area of instructional design, with the image of the computer helping and guiding teachers to design their resources, learning as it goes the styles of particular teachers and modifying its designs accordingly!

Finally, Fitgerald (1992), and others have worked on the development of a seven-step systematic instructional design and development model involving preplanning, designing, authoring, testing, and revising the courseware. The aim of the article was to provide classroom practitioners with the basic information to use hypermedia to develop CAI programs with a cross-curricula flavour.

THE WORKINGS OF HYPERMEDIA

It is not intended here to go into a deep training session on how to use a hypermedia program. At this point all that is necessary is to examine the general concepts involved in the creation and working of a "stack" or "binder".

Hypermedia have these features:

1. An authoring tool creates a stand alone runfile.
2. The runfile, often called a "stack" or "binder", is a series of screens which can be linked flexibly.
3. User definable "buttons" can be placed onto each screen to allow free movement from one to the other with a click, press, or an automatic event.
4. A screen can contain any number of "frames" which contain information in one form or another.
5. A frame may be any combination of text, graphic, sound, music, or video. Often selected contents of a frame may be removed from the stack and used separately.
6. Frames may be hidden on the screen, only to be revealed on a button press/mouse click, or conversely, be visible and then hidden on a button press/mouse click.
7. Programming skills are not necessary, but there is often a "scripting language" which can be accessed if desired.

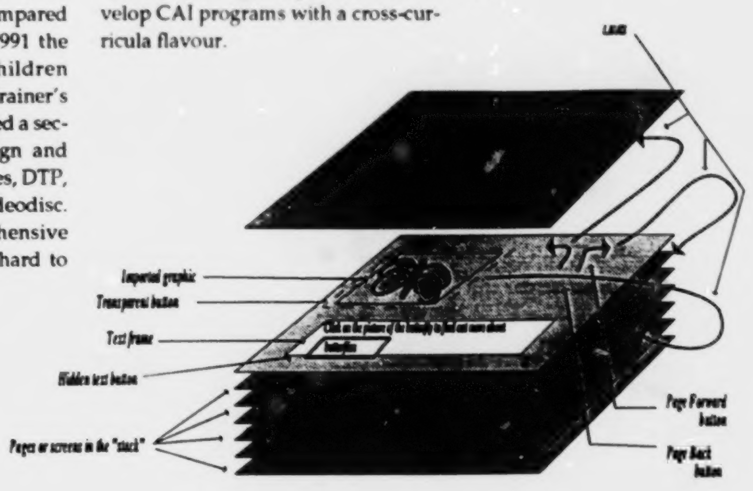


Figure 1.

It is the feature of linking, and the ease with which it can be carried out, that makes hypermedia a versatile tool for the teacher.

If, for example, a teacher wants to create an individual learning module on the parts of a butterfly, it could be done in just five simple steps:

1. Create the initial bourder simply by naming it and saving the "blank", or empty. (From now on as each new screen is created the program will automatically save the previous one.
2. Import any graphics, which may be drawn, painted, or digitized in (Most hypermedia systems have built in drawing tools).
3. Write, or import, the appropriate text.
4. Decide on what links this screen will have with others- for example, clicking on the head may change screens to a greater detail view of the head, or clicking on a picture of an egg, or the words "LIFE CYCLE", may move to a series of screens dealing with that subject.
5. Place the appropriate "buttons" in place, setting them to the correct locations, and setting them as either visible or invisible. Add hidden frames and key them to the area to be clicked to reveal or hide them.

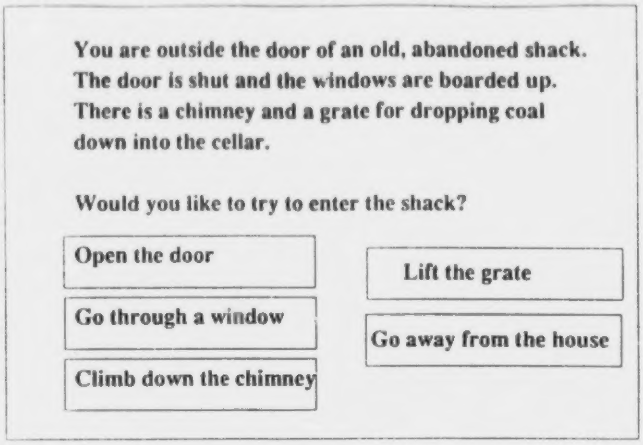
Thus a single screen can be created with very little training. It has been the experience of the author that trainee teachers of English, most with no prior use of the computer at all, can be enthusiastically creating simple linked pages after a single group "walkthrough" of the above procedure in less than thirty minutes.

The hypermedia program "Magpie", by Longman Logotron, is designed for use on the Acorn Archimedes series of computers. It is strongly representative of the genre, and is actually intended for use specifically by school students. Experience has shown, however, that many teachers are confident enough to use the program to create their own support materials. What follows is a brief look at some of the curriculum areas and how hypermedia, and Magpie in particular, may be applied:

ENGLISH

1. Creating multiple path stories with complex path possibilities.
   Students can set up any number of alternatives on each screen, selected by clicking on the box (Figure 2)
2. Creating Annotated Books
   A selected work by an author is written onto the screen. Key words are then indicated in some way, and either hidden text blocks or page links are attached to them. This provides detailed support for the reader, to be used only if the need arises (Figure 3).

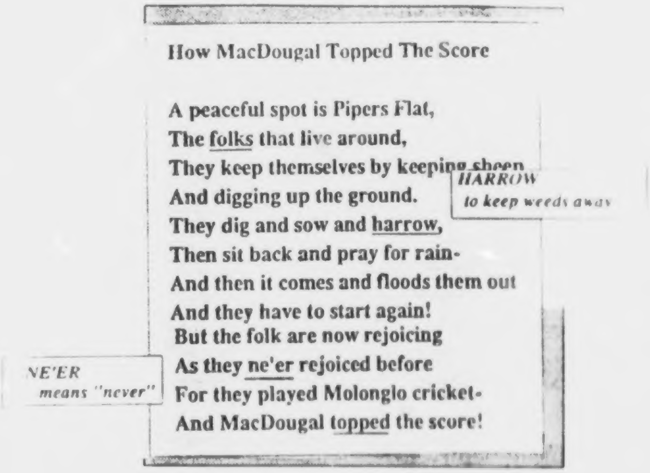
It is also easy to append a quick quiz on any aspects of the work.



You are outside the door of an old, abandoned shack. The door is shut and the windows are boarded up. There is a chimney and a grate for dropping coal down into the cellar.

Would you like to try to enter the shack?

Figure 2.



How MacDougal Topped The Score

A peaceful spot is Pipers Flat,
The folks that live around,
They keep themselves by keeping sheep
And digging up the ground.
They dig and sow and harrow,
Then sit back and pray for rain-
And then it comes and floods them out
And they have to start again!
But the folk are now rejoicing
As they ne'er rejoiced before
For they played Molonglo cricket-
And MacDougal topped the score!

HARROW
to keep weeds away

NE'ER
means "never"

Figure 3.

SCIENCE

1. Active Diagrams
   The correct setting up procedure for different apparatus can be shown, with a "What's Missing?" choice to be made. The screen might explain, verbally, what is right or wrong about the choice made by the student (Figure 4).

   This could equally be the point of a safety quiz for equipment usage.

2. Simulations of chemical experiments can be set up, allowing the student to make choices rather than follow through by rote. In this fashion, students can learn from their mistakes and live to try again. The provision of activities of this kind is an easy way to ensure that students really know what their choices are before the necessity of dealing with potentially hazardous chemicals (Figure 5).

HISTORY / GEOGRAPHY / HUMAN SOCIETY

I. Interactive Maps (Figure 6)
Maps which give extra detail at the touch of a button, or which scroll through events as a carousel.

Maps which pronounce place names.

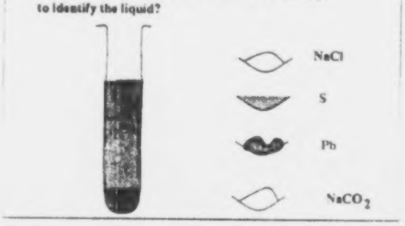
Maps which guide the user from place to place through time and space.

Visual / Audio databases which include sound samples of people talking- local history, social change, customs, accents.

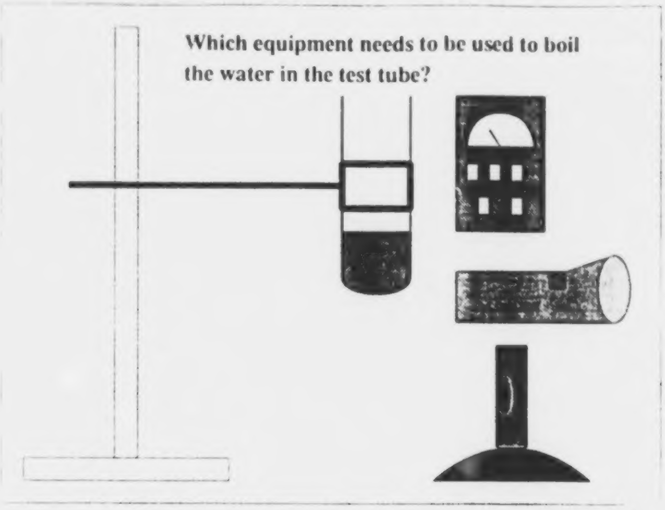
These databases can be set up in a highly visual way, helping to increase motivation on he part of the student.

Figure 7 shows a screen from a maritime database set up as a time line which can be randomly accessed or searched on a keyword free text basis.

It is possible to go on with more and more examples of the easy application of hypermedia to various curriculum areas. The role of the medium in LOTE, ESL and the various technology classrooms (Food Science, Industrial Arts, etc) has not been considered here, for example.

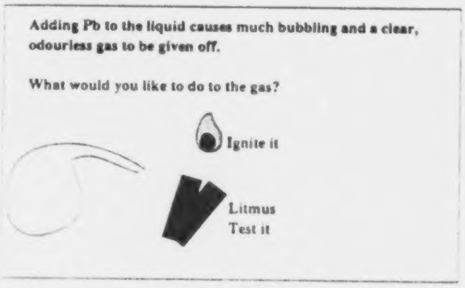


We have an unidentified liquid in the test tube.
It appears slightly oily.
Which powder could we add to it as a first attempt to identify the liquid?



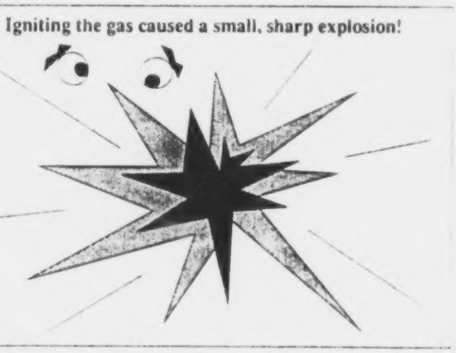
Which equipment needs to be used to boil the water in the test tube?

Figure 4.



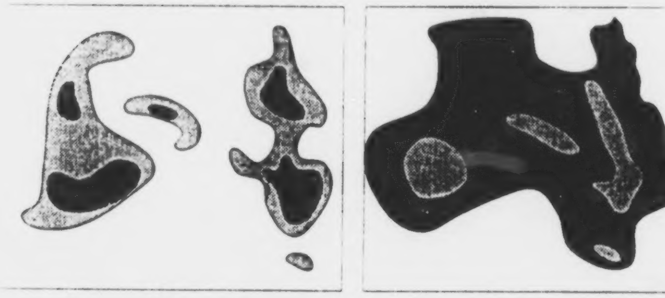
Adding Pb to the liquid causes much bubbling and a clear, odourless gas to be given off.

What would you like to do to the gas?



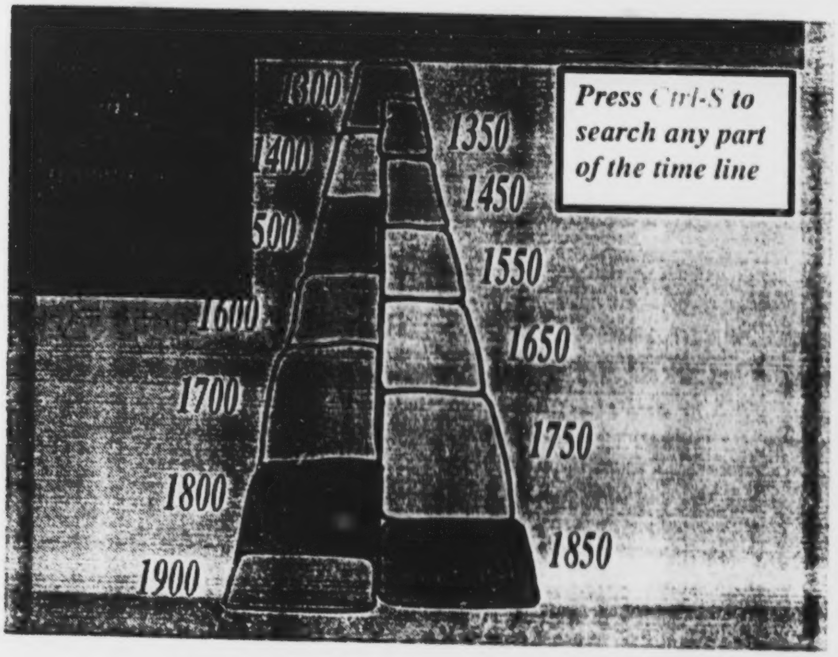
Igniting the gas caused a small, sharp explosion!

Figure 5.



Which of these maps shows Australia during an Interglacial Epoch?

Figure 6.



Press Ctrl-S to search any part of the time line

Figure 7.

An important advantage of specifically designed hypermedia applications is that they can be tailored not just to different learning areas, but also to different learning styles- the needs of Non English Speaking Background, Aboriginal education (a very iconic and graphic area), girls and Special Education students can be dealt with on an almost individual basis, once the target group is identified, and assuming that the most effective strategies for the group are understood in terms of computer support.

TOWARDS A HYPERMEDIA CHARTING SYSTEM

There exist a variety of forward planning or charting systems which allow us to design systems for various contingencies. STORYBOARDING is a term used in the video and graphic media to indicate plot development, potential "shoots", etc. In computing, the triumvirate of STRUCTURED ENGLISH, FLOWCHARTING and PSEUDOCODE define the nature of a program.

Structured English is the language style of expressing what is to happen in a given piece of program. A flowchart is the more contrived method of bridging the gap between pseudocode and the actual program code. The problem shared by both is that, having at their back some of the older methods of coding, derived mostly from the 1960's and 1970's, they are very LINEAR in nature, a problem they share with storyboarding.

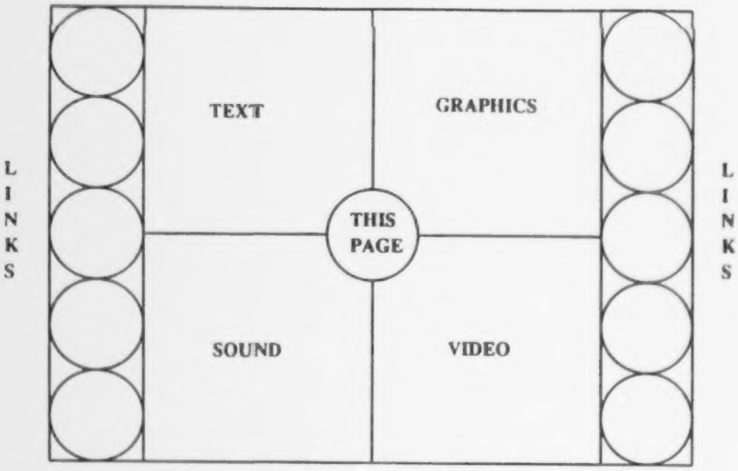
Hypermedia is however decidedly nonlinear, allowing jumping around in virtually any order, which means the above systems can become hopelessly crowded and entangled as a result.

While it could be argued that as Hypermedia are more intuitive than traditional programming languages it is not really necessary to "chart" progress at all, it quickly becomes apparent that any attempt to design an application of more than a dozen or so screens is asking for hopeless confusion.

The author has in fact now designed several applications with page numbers into the hundreds, and has had time to dwell on the problems of dealing with such sizes. There is little doubt that some sort of clear progression, existing outside the designers head, is necessary if the practises of good instructional design are to be followed. With this in mind it is necessary to consider any comprehensive stack or binder in the following manner:

1. Map out the broad areas to be dealt with in the stack. Do this in as visual a manner as necessary, on as large a piece of paper as necessary. Allow plenty of elbow room- use the floor!
2. Examine specific areas of your "map" in more detail. Thes may form the nucleus of modular sections of the final application.
3. Note down the type and style of each screen in a section- will it have sound, video or graphics? "Plot" these on the map.
4. Get a notepad, about A5 in size, and think of each page as a screen from your proposed application. Either in reality, or informally, divide each page up something like this:

BEST COPY AVAILABLE


LINKS
TEXT
GRAPHICS
THIS PAGE
SOUND
VIDEO
LINKS

The circles down the sides of the card indicate screens that this card links TO. It is possible to place numbers to indicate links FROM by putting such numbers in brackets. An arrow from a circle into one of the boxes can indicate that that link is a button over that particular item. Below is a card filled out to give an indication of how the system might work:

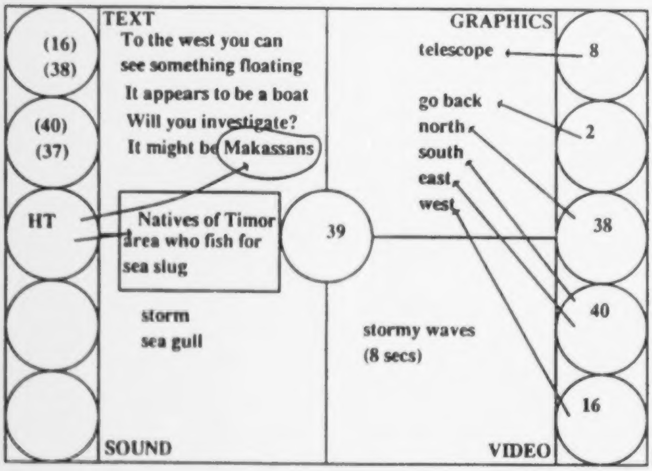

TEXT
To the west you can see something floating
It appears to be a boat
Will you investigate?
It might be Makassans
GRAPHICS
telescope
go back
north
south
east
west
(16)
(38)
(40)
(37)
HT
Natives of Timor area who fish for sea slug
39
8
2
38
40
16
storm
sea gull
stormy waves
(8 secs)
SOUND
VIDEO

Figure 8.

The layout is fairly self explanatory. Note that two different graphics link to the same page (40), that one button is actually over the word "Makassan" in the text, ready to show up the hidden text in the box if called for, and that there are links back to several other screens- some in fact are reciprocal links as can be seen from the numbers (eg there is a button on 16 which will bring you to 39, and there is

Once a series of screens have been set up in map or "story board" fashion, you can begin to get some idea of whether the concept is coming together or not. Several problems which often surface in large works are:

Pages with no links at all.
Redundant buttons/links
Links to the wrong pages.
Duplicate pages.

By "mapping" out the ideas first in this fashion much searching and redesign can be avoided later. Once some screens have been made in the program it is often possible to print them out individually, and these screen dumps can then replace the story-cards on your map.

CONCLUSION

It is apparent that many educators are beginning to see the potential for hypermedia as a design tool for classroom applications in a way which has hitherto failed. If these teachers and students are to design educationally valid material that is any better than some of the original poorly planned software which it has taken years to weed out of our classrooms, we need to consider carefully just how to design hypermedia applications. Only by being able to carefully examine the structure of these applications can we look at the educational imperatives, rather than be dazzled by the sound & light show of an apparently polished, but educationally unsound, final product.

Now is the time to make sure that this happens. The tool, hypermedia, exists and is easy to control. What is still to be defined is the mtehod by which this tool can be effectively used. History has shown us that classroom teachers want to share in the design process, and that the software industry is not necessarily the best palce for concept development and design to take place.

No doubt there are many who can look at this mapping concept and find problems with it, and that is fine. The point of the exercise has been to try to overcome the limitations of more traditional planning methods which just fail to meet the needs of hypermedia systems.

If the above approach can be refined or improved upon, or even thrown out for something better, so be it. The important point to remember is that it may be only a matter of time before hypermedia displace more conventional programming languages as the tool of choice for both teachers and students, and if this does occur than the ability to work with students, or colleagues, in the rational and efficient design of materials will only be made harder if no common ground for planning can be put into place.

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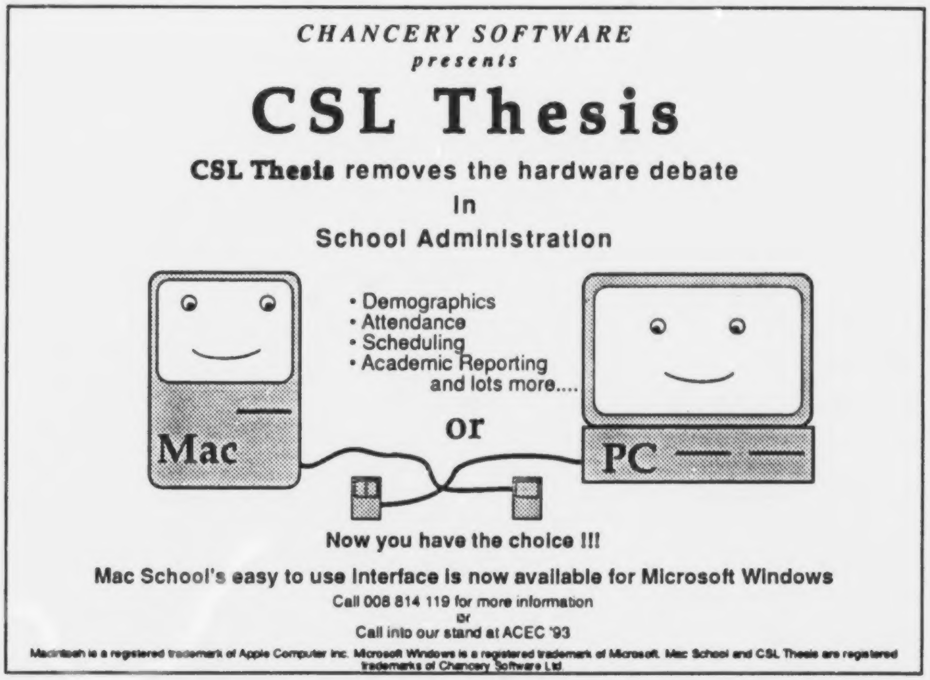
About the Author

Neville Fraser has for five years managed the Instructional Technology Centre for the Teacher Education Program at Macquarie University, Sydney, where he lectures on the application and role of various technologies in the classroom. He came to this position after ten years of primary teaching and consultation.



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THE EXECUTION AND ANIMATION OF DATAFLOW DIAGRAMS AS A COMPUTER AID TO LEARNING PROCESS MODELLING

BY STUART GARNER
Lecturer in Information Systems at Edith Cowan University, Perth

This paper outlines some research which is being undertaken by the author into a computer system to execute and animate process models of information systems. It briefly describes what the term "process modelling" means in the context of information systems and outlines some of the difficulties students have with the current approach to learning this systems analysis technique. An architecture for the new computer system is described together with details of a new computer language for specifying the behaviour of low level processes. The way in which it is envisaged that a student would interact with the system is also outlined.

INTRODUCTION

Systems Analysis is taught as a discrete unit within many Information Systems courses within educational institutions. At Edith Cowan University (ECU) the analysis phases of a conventional systems development lifecycle are taught together with the various techniques used by systems analysts to achieve the final product of analysis: a requirements specification. Such a specification includes models, both process and data, of the new system required by its users.

As part of the unit, students at ECU develop models for given problems making use of CASE (computer assisted software engineering) tools to document their models. These models are then checked by tutors in order to assess their degree of correctness. An example of part of such a process model for the Sales and Accounting system of "Delicious Dishes", an organization which produces pre-packaged food dishes, is shown later in figures 1 and 2.

The main problem for tutors is that the models are static and difficult to check, CASE tools performing only a limited amount of consistency checking of the models. Also, of course, the static nature of the models does not aid student understanding of whether the models would behave correctly if implemented on a computer system.

This paper will describe some research work which is being carried out as part of a doctorate programme at the University of Western Australia (UWA). A software system is being produced to attempt to overcome the problems above by allowing the process models produced by students to be executed and animated, the models during such execution then being dynamic models of information systems. It is envisaged that the ability to be able to "trace through" a process model and inspect its behaviour will enhance student understanding of both the technique of process modelling and the ways in which information systems operate.

WHAT IS PROCESS MODELLING?

Process modelling is the modelling of the main functions of an information system by the production of a set of dataflow diagrams (DFDs) together with information stored within a data dictionary.

A DFD is made up of four basic components:

- External entities or agents (also known as data sources or sinks).
- Processes or transformations which transform inputs into outputs.
- Datastores which are repositories of data.
- Dataflows which are pipes joining the above objects and which indicate the flow of data between objects.

An example of a DFD for the Sales and Accounting system of "Delicious Dishes" is shown in figure 1.

The diagram in figure 1 is obviously at a high level of abstraction. Such a process can be exploded in a lower level diagram to reveal more detail, the processes in the lower level diagram then being further exploded. Hence a hierarchical set of DFDs eventuates. Figure 2 shows the explosion of the Sales and Accounts process of figure 1. The processes of the lowest level DFDs are described in the data dictionary in natural language, structured English or sometimes by decision tables or trees. They are known as primitive processes or mini specifications.

STRUCTURE OF THE SYSTEM

In order to execute and animate a process model, a model needs to be defined more rigourously than would usually be the case with a conventional CASE tool. Research has been carried out into executable DFDs, examples being (Pacini and Turini, 1987), (Docker, 1988), (Fuggetta et al, 1988), (Lea and

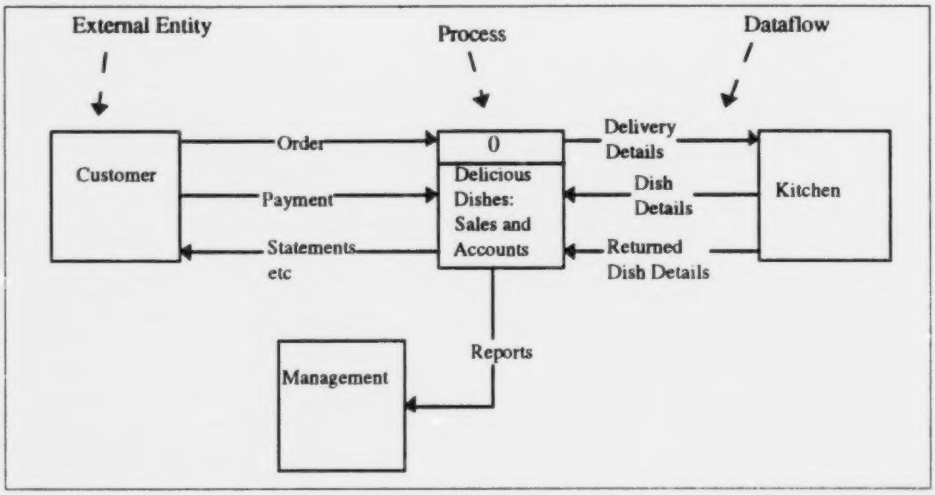
External Entity
Process
Dataflow
Customer
Order
Payment
Statements etc
0
Delicious Dishes: Sales and Accounts
Delivery Details
Dish Details
Returned Dish Details
Kitchen
Reports
Management

Figure 1

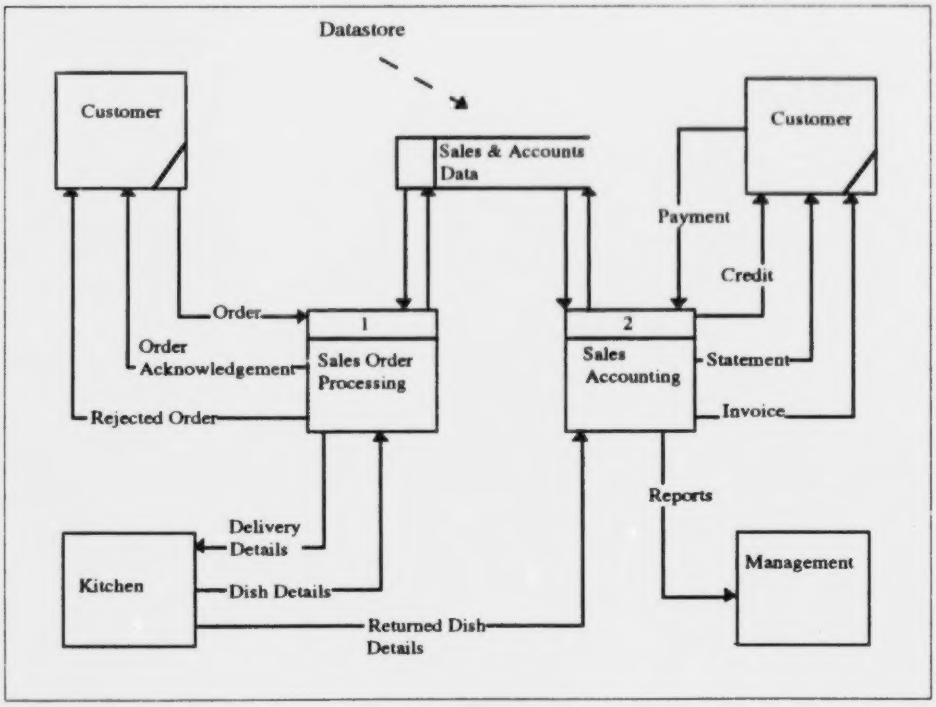
Datastore
Customer
Sales & Accounts Data
Customer
Payment
Credit
Order
Order Acknowledgement
Rejected Order
1
Sales Order Processing
2
Sales Accounting
Statement
Invoice
Reports
Delivery Details
Dish Details
Returned Dish Details
Kitchen
Management

Figure 2

Chung, 1990). The researchers' interests have not been in using executable DFDs as a teaching vehicle, but of attempting to execute specifications directly. This has involved introducing more formality into the specification process by increasing the set of objects used in diagrams to allow the specification of control of the processing (i.e. so it can be determined just when processes can execute) and the specification of primitive processes in more detail, generally with functional languages.

It was decided not to utilise either of the above in the new teaching system as it was thought more appropriate to try to reflect as closely as possible the practice used within the commercial IS world. It has therefore been necessary to define a language suitable for specifying the primitive processes in a straight forward manner and it is envisaged that the control of the execution of the processes of a model will be under user control, thereby allowing the user to "explore" the model so as to aid his or her understanding.

The process model to be executed is created by the user (tutor or student) as shown in figure 3.

As can be seen, the diagrams are produced using a graphics editor which will be similar to those used within CASE tools, primitive processes are defined via a structured text editor, and further details of the model are stored in a set of Oracle tables via an Oracle RDBMS (relational database management system).

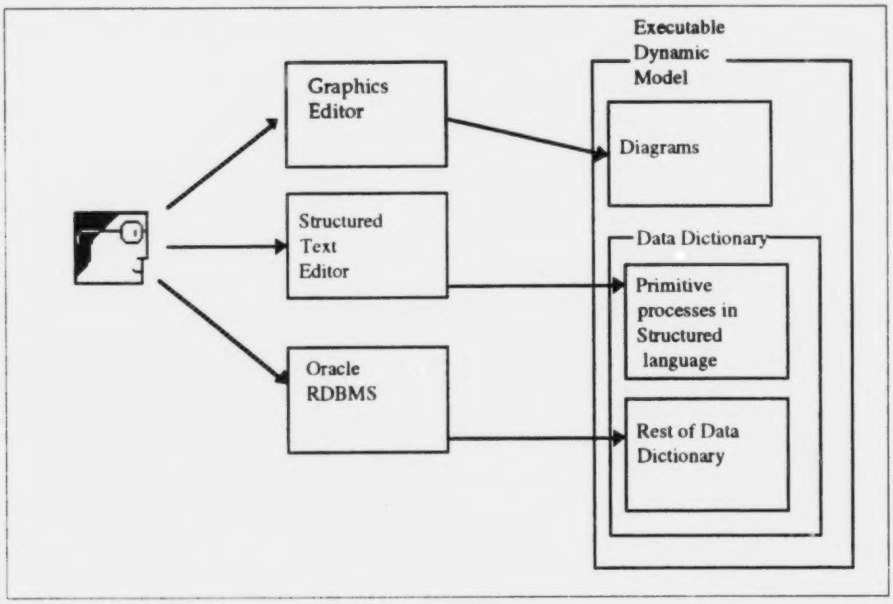
Executable
Dynamic
Model
Graphics
Editor
Diagrams
Structured
Text
Editor
Data Dictionary
Primitive
processes in
Structured
language
Oracle
RDBMS
Rest of Data
Dictionary

Figure 3

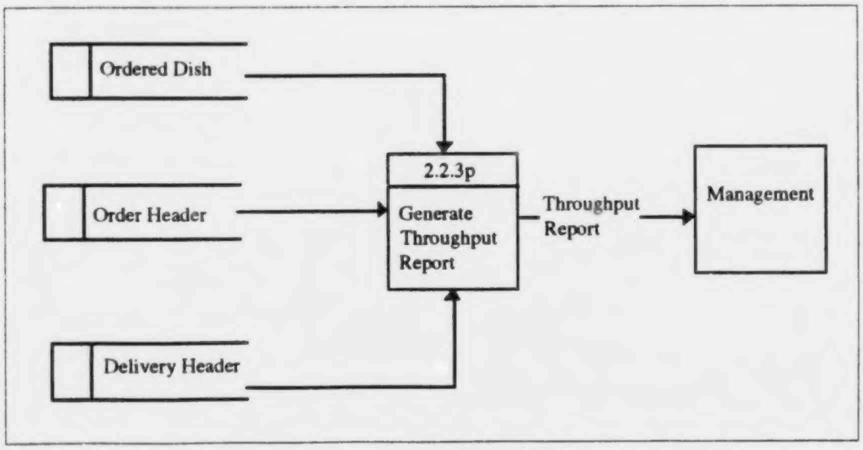
Ordered Dish
Order Header
Delivery Header
2.2.3p
Generate
Throughput
Report
Throughput
Report
Management

Figure 4

In order to allow execution of the process model, the primitive process specifications need to be compiled into executable code, a runtime system then executing and animating this code.

THE LANGUAGE FOR DEFINING PROCESSES

A language has been defined for specifying the primitive processes, the ease of use of the language by students being of paramount importance in its design. The input and output data to and from the individual processes are provided via the dataflows. It should be noted that the structure of all dataflows and datastores will have been defined in the data dictionary and hence the attributes (fields) will be "known" during the compilation of a process. The best way to gain an understanding of some of the language features is by way of an example. A fragment of a low level DFD from the "Delicious Dishes" process model is shown in figure 4 and will be considered.

The data dictionary entries are as follows:

Each data element or structure in the above would also be defined in the data dictionary so its data type would be known to the process to be defined. Process 2.2.3p in the diagram is a primitive and is described below. Note that line numbers have been used to help in the explanation and are not used in the real system.

order_header	ordered_dish	delivery_header	throughput_report
order_number & customer_number & date_of_order quantity_ordered & ordered_dish_status & delivery_number & invoice_number & (contract_number)	order_number & dish_reference & dish_description & customer_address & (delivery_address)	delivery_number & delivery_date & customer_number &	date & average_time

---

```
* For an order closure, all the ordered dishes on the order must have
* been delivered. The last ordered dish delivered for an order will indicate the
* order closure date. This is date is stored in the delivery header.
* To determine the average time for the processing of orders: }

1  set TOTAL_TIME to 0
2  set NUMBER_OF_ORDERS to 0
3  join order_header table, ordered_dish table giving FULL_ORDER_LINE table
4  for each tuple in FULL_ORDER_LINE table do
5          on first FULL_ORDER_LINE tuple for this order_number do
6                  set ORDER_CLOSED to TRUE
7          end on
8          if ordered_dish_status <> "delivered" then
9                  set ORDER_CLOSED to FALSE
10         end if
11         on last FULL_ORDER_LINE tuple for this order_number do
12                 if ORDER_CLOSED then
13                    read delivery_header table
14                    set TOTAL_TIME to TOTAL_TIME +
15                            (delivery_date - date_of_order)
16                    set NUMBER_OF_ORDERS to NUMBER_OF_ORDERS + 1
17                 end if
18         end on
19 end for
20 set average_time to TOTAL_TIME / NUMBER_OF_ORDERS
21 send throughput_report dataflow
```

Points to note about the above include:

- Details of the data structures in the dataflows are all stored in the Oracle data dictionary and hence the names of attributes are available in the body of the process. An example of such an attribute is "ordered_dish_status" (line 8) which belongs to the "ordered dish" table or datastore.
- Variables are not explicitly declared as in many languages.
- Local identifiers are in upper case and their types are determined when they are first referenced (for example "TOTAL_TIME " in line 1).
- Dataflow and table identifiers are in lower case (for example "order_header" in line 1).
- Assignment takes place via "set" statements (see line 20 for an example).
- It is assumed that the underlying data model is relational and therefore commands such as "join" are available. The "join" command combines two or more tables into a view and in the case of this language, a temporary table is created for further manipulation during the processing. Efficiency is not a major consideration here as the main concern is that of enhancing student understanding. The join takes place over table attributes with a common name and similar structures (order_number in this example in line 3) in the tables to be joined and hence is not made explicit.
- The "for" statement allows each tuple (row) in a table to be manipulated (see line 4).
- The "on" statement is used to simplify control break processing (see line 5 for an example).
- The "send" statement is used to release an instance of a dataflow. In this case the flow is "throughput report" and its attributes have been set during process execution (see line 21).

There are many other features to the language, the above simply indicates something of its flavour.

HOW THE SYSTEM WILL BE USED IN TEACHING

One of the aims of structured systems analysis is to produce a logical model of an information system required by a user. This model is devoid of all physical attributes such as the the input / output media and the media in which data will be stored. The data is fully normalised, each entity type such as customer, employee, being stored in a datastore. There are no redundant data in such a model and processes such as the routing of data are removed as they are unnecessary. Such a logical model is sometimes termed the "essence" of the system. Models of this type will be executed and animated by the new system.

It is normal at ECU to require students to produce such logical models, having been given various informations systems scenarios. An example of a scenario is a description of an existing flight booking system together with all the problems and requirements of the current users. It is envisaged that part of the required logical model, which is the solution, would have already been produced by the lecturer or tutor depending on which aspect of process modelling was being emphasised. For example, part of the data dictionary, data flow diagrams, primitive processes and test data may have been produced. Students would then complete the modelling process and execute their models at various points to check their specifications.

The expected form of model execution will be discussed with respect to figure 5. Initially execution cannot take place until an occurrence of DF1 (dataflow 1), for example an order, coming from EE1 (external entity 1), for example a customer, is instigated. (Note that execution of other processes within P1 might in fact be able to take place if their execution is independent of any input data). A student enters some data in order to instigate DF1, this data entry being through a Hypercard interface to Oracle. DF1 is then "seen to flow" to process P1 which flashes indicating that a process within it can execute.

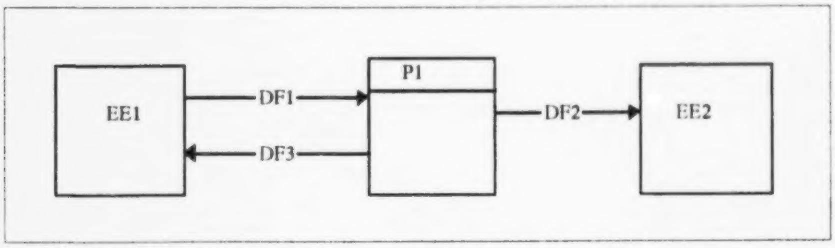

Figure 5

The student then "opens up" P1 to reveal the lower level DFD of figure 6.

Process P1.1p is now able to execute due to the presence of DF1. This is a primitive process (indicated by the lowercase "p") and hence is described in the new structured language. Opening up P1.1p will reveal the description of the process in this language and it will now execute, the student being able to step through the process and inspect the data within the system at any point. As can be seen, at some point there may be be access to DS1 (datastore 1). This will already have been populated with some test data by the tutor or student and is in practice an Oracle table. An instance of DF4 will eventually be produced enabling P1.2p to execute. The student would have a choice now, whether to instigate another transaction by providing another instance of DF1 and re-executing P1.1p, or whether to follow through the first transaction by investigating the processing of P1.2p.

There can of course be many processes available to a student to execute and the choice can be his or hers or left to the runtime system. Some processes will be able to execute without an input dataflow from another process. An example would be the production of an invoice or invoices triggered by some point in time.

It is hoped that the ability to animate a process model in this way will enhance student understanding of the information system which is being specified.

CURRENT PROGRESS

The compiler is currently being written, target hardware being the Macintosh computer range. Students will be using the new language in the Systems Analysis unit this semester (semester 1, 1993) but will only be able to carry out syntax checking on the processes which they develop.

CONCLUSION

The learning of process modelling by students is currently carried out by students attempting to model many typical information system scenarios and then obtaining feedback on those attempts from tutors. The static nature of the models makes it difficult for both students and tutors to determine if models produced accurately reflect the real world situations. This paper has outlined research which is currently being undertaken to provide a computer system which will execute and animate such models so as to increase student understanding of particular information systems and to help in the determination of the "correctness" of a solution.

The underlying model of data storage is relational being based on Oracle and to this end the system should also help student understanding of relational database concepts.

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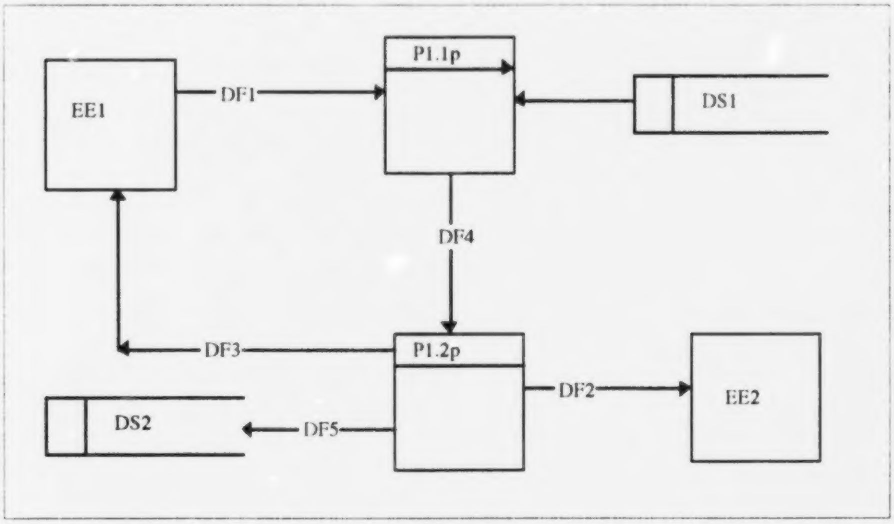

Figure 6

GEOLOGICAL AND GEOPHYSICAL MODELLING IN THE CLASSROOM

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We introduce a new computer package - "Noddy" - which is particularly useful for the education of tertiary students studying structural geology and geophysics. Its use in the upper years of secondary school has the potential for interesting a whole new generation of students in careers in the Earth Sciences.

We present a technique for the integrated forward modelling of the structure and geophysical response of multiply deformed terrains. This technique allows information collected by field geologists and geophysicist to be reconciled by the development of a simplified structural history of the area.

The accuracy of this history can be gauged by comparing the model predictions with the dual constraints provided by the measured structural and geophysical data. This approach points to a new methodology for the reconstruction of the earth's crust, and has potential as a tool for both training and research.

INTRODUCTION

Airborne magnetic and gravity surveys have become increasingly important contributors to the development of structural models in poorly exposed or complex terrains (Isles et al 1988, Leaman 1991, Whiting 1986). In exploration and much of global geophysics, as in structural mapping, the primary goal is the determination of the three dimensional geometry of the earth. Inferences with respect to kinematics and dynamics can then be made, however it is the geometry which we must first correctly establish. Given the ever improving spatial resolution of gravity and magnetic surveys, which can now resolve quite narrow lithological units, it is perhaps surprising how few tools are available to interpret the observed structural and geophysical data in an integrated fashion.

The purpose of this paper is to outline the principles of an integrated system for the reconciliation of gravity, magnetic and structural data sets, and to give examples as to how an implementation of this system based on structural and geophysical forward modelling can be used in the classroom.

THE DESCRIPTION OF THE THREE DIMENSIONAL STRUCTURE OF THE EARTH

One of the major stumbling blocks in the interpretation of regional geophysical data sets seems to be the descriptive language of most modelling packages. Seismic studies by their very nature emphasise the layering in rocks, however the typical approach to gravity and magnetic modelling has been to model the isolated anomalies associated with regular geometric solids, such as a buried sphere or a dipping prism (Telford et al. 1990). The difficulty of constructing realistic geometric models in three dimensions restricts the relevance to structural geologists of the geophysical modelling that follows. The language of structural geologists recognises the inherent layering found through much of the earth's crust, and often describes the observed structures in terms of the geometry of deformation which effects this layering (Tipper 1992), such as fold geometries. It is clear that gravity and magnetic data should be of interest to the structural geologist, since structural data is normally limited to surface observations and in many regions the outcrop is sparse, whereas the geophysicist measures anomalies which are the response of a solid volume of rock, and thus can potentially recover information about this volume.

We believe that by using a structural geologist's descriptive language to implement a geophysical forward modelling scheme (*"structural geophysics "?*), we can develop a system whereby the constraints on the three dimensional structure naturally incorporate both structural and geophysical data, and thus should be of interest to anyone whose primary goal is an understanding of the geometry of the earth's crust.

THE INTEGRATED MODELLING OF STRUCTURE AND GEOPHYSICS

In order to demonstrate the potential of using integrated structural and geophysical constraints to reconstruct the three dimensional geometry of the earth we have developed the Noddy forward modelling computer package that allows the user to define the structure in terms of a simplified geological history. This history can be based on any *a priori* information available to the geologist, and is likely to include structural information, such as outcrop patterns, and the orientation of bedding, and geophysical information such as the measured magnetic susceptibility of rocks in the area, and the observed gravity and magnetic anomaly patterns. Once the history has been specified the software allows the geologist to verify the accuracy of the history by comparing the resulting structural and geophysical predictions with the measured data.

The starting point for modelling is a layer cake stratigraphy, for which the heights of the stratigraphic contacts are defined, together with the densities and magnetic susceptibilities of each unit. The structural history is then developed from a set of "events", namely folding, faulting, unconformities, shear zones, dykes, igneous plugs, tilts, homogeneous strains, penetrative cleavages and penetrative lineations. Each of these events can be defined in terms four classes of properties: their shape, position, orientation and scale. These are definitions in a form that any structural geologist would understand. Although individual structural events can be extremely simple it is a salutary lesson in itself to observe the complexity of the geometries that quickly develop as two or three events are superimposed on one another.

The numerical basis for the calculation of the interaction of these structures relies on the Eulerian description of these events in terms of a set of displacement equations, as developed in Jessell 1981. Similar approaches have also been used by Theissen 1980, Perrin et al 1992. in the program "Geostudies" A major strength of Noddy is the similarity between the types of data collected in the field and the predictions which result from the combination of these displacement equations. Thus predictions are made as to the outcrop patterns and bedding, cleavage and lineation orientation data, either for a flat land surface, or for a specific topography provided by the geologist. In addition, what would normally be interpretative figures such as block diagrams, sections and bedding surfaces can be easily calculated.

The calculation of the gravity and magnetic anomalies is based on an implementation of Hjelt's dipping prism solution (Hjelt 1972, 1974). The geological volume of interest in divided up into small cubes (*"roxels"*?), and the geology of each cube is assumed to be the geology of the central point in the cube. The surface response at a given location is then calculated by combining the responses of each cube in turn, within a threshold distance of that location. The first constraint on the plausibility of a given geological history is its ability to account for the outcrop patterns, orientation data, and age relationships seen in the field. However these represent an essentially two dimensional data set. The additional constraint of the gravity and/or magnetic data allows for a significantly improved testing of any proposed model . If the geological model appears accurate, but fails to account for a significant part of the geophysical anomaly, then clearly a further reconciliation of the data needs to be performed.

One of the major advantages of the system presented here is that the modification of the history may be as simple as changing the throw on a fault, and that final representation of the model is not just a set of volume defining polyhedra, but a series of structural events with geological significance.

THE NODDY PACKAGE FLOW.

The general flow of Noddy consists of:

1. The definition of a layer cake stratigraphy.
2. The interactive development of a structural history.
3. The use of 2D and 3D visualisation tools such as block diagrams, line maps, sections, toposurfaces, geometries of a single stratigraphic layer (Fig.1).
4. The calculation of 1D and 2D gravity and magnetic images.
5. The editing of the existing structural history and recalculating of the anomalies to improve the match between real and calculated structure and geophysical response.

Since this program is completely interactive, apart from the initial definition of a base stratigraphy at step 1, the steps may be enacted in any order.
Noddy is completely menu driven. The computer's pull-down menus allow the user to make a visual slice through a block with any orientation and view it from any point . At any stage the user can ask Noddy to generate a map of the surface features. The map can be interrogated by clicking at a chosen point with the mouse. Noddy shows the direction and degree of any dip of the bedding or foliation at that point.
The program can read in a file representing the topography of the area allowing the user to see how the topography interacts with the geology. Geophysical information can be mapped as monochrome images. The program allows the users to save the front window to file, print the front window to a printer or read an existing picture from file into a new window. This can be used to import sections, geological maps and geophysical images for comparison with the model results. Today Noddy runs on any Macintosh with a math co-processor or a Sun work stationt.

APPLICATIONS OF THE TECHNIQUE

We have investigated two main uses for this integrated modelling package: as a training tool in the teaching of structural geology and geophysics, and as a method of testing specific interpretations of natural structures.

The teaching of structural geology at the university level is clearly a growth industry, with over 15 general or specialised English language structural geology textbooks published since Ramsay (1967). One of the difficulties in teaching structural geology has always been the leap of imagination required to go from the description of individual structures to the interaction of these structures in three dimensions. The structural forward modelling demonstrated in this paper was originally developed with this goal in mind, and on its own it still provides a useful teaching aid.

From the teaching point of view you can produce a bare topographic map and then get the student to interrogate Noddy on the geology at any point. The package has the potential of being a simulation where the student is given access only to a limited subset of the geology approximating the limited resources available to the real-world geologist.

Noddy has been successfully used for short courses to geologists working in industry and undergraduate and graduate level academic courses. The extension to geophysical modelling allows the structural geologist to make useful predictions as to the expected appearance of idealised structures in gravity and magnetic data sets. Similarly the introduction of geological constraints into the teaching of geophysical interpretation ensures the student never loses sight of the geological nature of the data.

The development of three dimensional structural models to account for observed surface structures is always difficult, since even if the surface outcrop is relatively unambiguous, the downward continuity of structures at depth can only be guessed at. The added constraints provided by gravity and magnetic data sets can at worst confirm this continuity, and will often suggest otherwise. We believe that the integrated modelling approach we have taken here will become an increasingly important tool in the interpretation of structures on the scale of 1-10 km (Valenta et al 1992).

DISCUSSION

In this paper we have demonstrated the principle of the reconciliation of combined gravity, magnetic and structural data sets, using a forward modelling approach. The structures which may be modelled are in themselves based on very simplistic displacement equations, however their combination allows complex relationships to be investigated. The incorporation of more complex structural modelling events is clearly feasible, however it will not change the fundamental utility of the program.

We believe that by forcing the constraints on geophysical modelling to be geological, rather than merely geometric, we can provide a way forward for the integration of not only gravity, magnetic and structural data sets, but other geophysical properties as well, and that this approach provides a pathway for the reconstruction of the three dimensional geology of the earths crust using all available data sets.

We have described the Noddy structural geology package. Noddy is particulary well adapted to the task of educating nascent structural geologist and geophysicists.One great difficulty that constantly confronts earth science educators is how to cultivate in their students the ability of turning a textual or 2D visual description of a geological structure into a useful understanding of the 3D geometry of the structures and their interactions. Noddy confronts this problem directly and by allowing the student to interactively generate and manipulate a three-dimensional representation of a structural geological model - overcomes it.

The package also makes manifest the relationship between structure and geophysics. A student may generate any number of idealised geological structures and Noddy will calculate the geophysical data consistent with them. What's more, the Noddy package will run now on two popular computer architectures - Sun Workstations and Apple Macintoshes - thus opening the way for its use in teaching laboratories. In conclusion. Noddy is useful in geological and geophysical research and teaching, because to our knowledge it is the only package that combines structural geology and geophysics, interactive 2D and 3D computer graphics in one affordable product available now.

ACKNOWLEDGEMENTS

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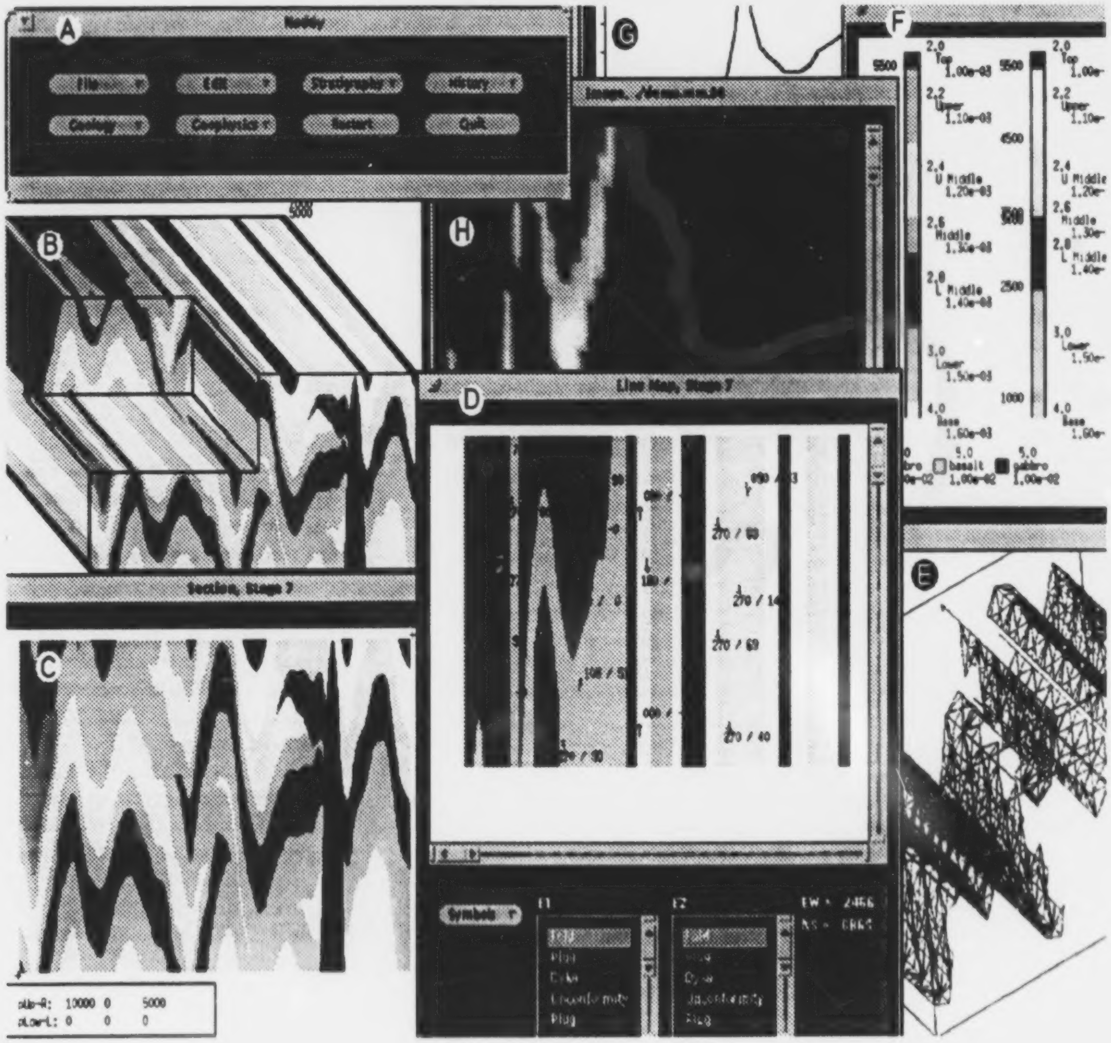
A
Noddy
File
Edit
Stratigraphy
History
Geology
Geophysics
Restart
Quit
B
C
Section, Stage 7
D
Line Map, Stage 7
Symbols
E
F
G
H
basalt
gabbro

Figure 1 An example of a Noddy session with different 2D and 3D graphics windows

A. Main menu
B. Block diagram
C. Section
D. Map
E. 3D surface of a layer
F. Stratigraphy column
G. Magnetic profile
H. 2D Magnetic anomaly image

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AN INTRODUCTION TO CBL AUTHORING WITH AUTHO RWARE PROFESSIONAL

BY JOHN HARVEY
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Authoring tools
Teachers and others interested in developing computer-based learning (CBL) programs for education and training have always been interested in ways of increasing productivity and decreasing the need to spend time gaining expertise in general programming languages.

One of the earliest attempts to meet this problem was the development of the program PILOT (Planned Instruction Learning Or Teaching). PILOT was designed and written by Professor John Starkweather at the University of California in 1969-70 and subsequently modified to run on a variety of machines N(eg., CoPILOT on the HP2000F in 1973, and SuperPILOT on the Apple II in 1980). Many teachers who have done Computer Education diplomas will recall being introduced to SuperPILOT (Apple, 1980). SuperPilot is an example of an authoring language. This is a form of programming language with specific in T-built routines designed to meet typical requirements of CBL such as interactions. ,Thus in SuperPILOT the sequence,

```
        t: What is 2 + 2?
        a:
        m: 4! four! FOUR!
        ty:  Yes, that's correct.
        tn:  No, the answer is 4.
```

sets up (types) a question on the screen , accepts input from the keyboard, matches a variety of answers, and provides feedback depending on whether the Nstudent's response was correct or not. The commands illustrate how authoring tools provide the user with single command structures that could otherwise take several lines of code in a more general purpose language. While that sequence in SuperPILOT is straightforward enough, if variables were involved then code such as

```
        a: #n $S$ #q2
```

would be needed. This is not so intuitive and led users often to remark that learning SuperPILOT involved just as much effort as learning BASIC, the alternative for most Apple II users (Berthold, 1986). Thus for many introduced to SuperPILOT via a course assignment it was generally a one-time association and although it had attractive features (eg., graphics and sound editors, animation) it does not seem to have been widely employed. Attempts to reduce some of SuperPILOT's coding´rules (eg., AUSPILOT, Keepes & Wignall, 1984) suffered much the same fate.

More recent instances designed for PC systems however, have gained more popularity, as they offer considerable power and flexibility, for example, TenCORE. (Computer Teaching Corporation, 1985). Nonetheless they still require a sound knowledge of programming techniques and technical skill in the particular authoring language.

In an effort to ameliorate this problem, authoring systems have emerged. Authoring systems attempt to reduce the need to write code-like instructions. One approach has been to provide a menu of common CBL formats, for example, multiple choice, true/false, branching, and through a series of prompts (eg., how many distractors?; how many attempts?) the design is developed. The program generates the necessary underlying levels of code. An early example developed for the Apple II and used locally for school programs was the Zenith Education System (Anderson, 1983). An example for MS-DOS machines is Author (Kokot & Ellis, 1988).

There are now many authoring systems available and Alessi & Trollip (1991) suggest that it is useful to recognise a continuum covering code-oriented systems (eg., PC/Pilot, TenCORE, Unison), frame-oriented systems (e.g., PCClass), and @ gmore recently, icon-oriented approaches (e.g., Course Builder, Authorware Professional, Icon Author)

Frame-oriented programs allow designers to work more directly with the screen display as it will be seen by the user, using a pointing device such as a mouse - as against the older procedure of specifying layout indirectly by typing programming commands. A 'frame' as defined by Burke (1982, p.68) is "a conventional term that has come to mean the amount of information that is presented on the microcomputer display screen at any one time. A frame may contain straight narrative text or it may contain a question, or a combination or both". Frame-oriented systems recognise this key element and attempt to provide authors with tools which simplify the processes of screen design. They come with extensive graphics and text editors which encourage experimentation with screen layouts, and provide means for efficiently building programs with many screens which have the same layout (eg., by setting permanent background elements). HyperCard, although generally eschewing the term 'frame', can be seen as a sophisticated and powewrful frame orientated system - "the program is largely a metaphor for collections of information stored on cards, much like a card catalog at a library" (Goodman, 1987, p.19).

To increase further the power and flexibility of the program, contemporary frame-oriented systems are being furnished with a programming language (eg., HyperCard's HyperTalk and Macromind Director'sLingo) and are also designed to allow branching to modules incorporating other languages (eg., 'XCMD's and 'XFCN's - external commands and functions) and to allow externally created Sound and graphics files to be imported. As Allesi & Trollip (1991, p.343) comment: "As the manufactuers of code-oriented systems try to increase their ease of use, they add more and better display editors. As the manufacturers of frame-oriented systems try to increase the power of their systems, they add the abilty to "drop down" to the code level and write code for simulations and other methodologies". Students of HyperCard become very conscious of the distinction between frame-orientation and code-orientation when they begin to work with HyperTalk scripting.

Icon-oriented systems also encourage working directly with the screens that will be seen by the user, but more critically, provide additional tools which allow the author to develop on screen a top-down, self-documenting flowchart of the entire lesson. This feature greatly helps to overcome the problem of keeping close track, and control, of the overall design - a well known headache for HyperCard authors.

The tools are provided as a palette of icons representing basic design elements - for example, displays, pauses, erasings, animations, decisions, interactions, calculations. The author controls the shape and flow of the program by selecting the appropriate icon. Icons can be grouped to indicate the high level structure of the program - the term "map" is aptly given this icon in Authorware. Thus an episode might call for some information to be displayed until the user decides to move on, a question involving an animation, user input, feedback, and a contingent branch. Icons representing these actions are first placed on a design line, named, and then in turn 'opened' and provided with the required detail, ie., data and instructions. These might then be grouped using a map icon and given an appropriate unit title.

The design of icon-oriented systems generally permits complex programs to be developed without need to resort to detailed scripting, however if more flexibility is needed then external files can be imported as with HyperCard Authorware Professional is such an icon-oriented system and is the subject of the workshop.

It is not unreasonable to say that icon-oriented systems are a significant advance towards the aim of having an authoring tool in which technical programming issues are minimised and which allows the person creating the program to devote more effort to considerations of the instructional design. At the same time it needs to be said that there is still an effort involved in learning the 'programming' aspects of the present icon-based programs and if a design calls for elaborate graphics and sounds, other programs will be involved and the technical side is then far from simple. The aim of the workshop is to allow participants to gain an appreciation of how Authorware Professional 'works' by creating simple interaction episodes, and by discussing the processes involved in authoring more elaborate programs.

AUTHORWARE PROFESSIONAL

Authorware Professional is a now a product of Macromedia and was first released in 1989 by Authorware, Inc. It is based on two earlier authoring systems, Course of Action and Best Course of Action and there was an Authorware Academic which also has now been discontinued. There are versions for the Macintosh and for Windows with only slight apparent differences for the user between the two implementations.

An important feature is that a file created on a Macintosh can be opened and further edited or run under Windows. (It does not convert the other way, however - a program created using Authorware for Windows cannot run on a Macintosh.) The finished product can be set up as a standalone disk, that is, users do not need to have, or know anything about Authorware to run an Authorware program.

Authorware Professional is built around 11 icons:

Display icons place graphics and text on the screen.
Animations icons move the object(s) in a preceding display(s)
Erase icons erase objects from the screen
Wait icons control transitions from screen to screen.'
Decision icons control branching and selection sequences.
Interactions icons are used to program a variety of user inputs (eg., alphanumeric entry, select an option from a pull-down menu, move an object, click on a 'hot spot', click on a 'button', accept a single keypress, accept only two tries, allow only 10 secs to respond,
Calculation icons are used to calculate and evaluate expressions, execute in-built functions or custom code, jump to other files and applications
Map icons are used to hold sets of other icons and so encourage designs to be modularised and given clear top-down structures.
Movie icons are used to present rapid frame animations and QuickTime movies or DVI files
Sound icons play digitised sounds - music, speech, special effects.
Video icons allow the program to bring in video sequences and individual frames from video players.

The authoring process gets underway with icons being placed on a design or 'flowline'. The icons can be taken from the palette or pasted from a library of previously established routines or 'models'. The file can then be 'run' and execution will proceed until an 'empty' icon is encountered. For example, in the case of a display icon, it is considered 'empty' if it has no text or graphic content. A small graphics palette is provided and the screen for that icon can be created, or a previously developed graphic can be imported as the content of that display icon. Special effects (eg., fade in/fade out) can be added and execution can proceed until the next empty icon. Execution can be interrupted at any time to allow an icon's content to be edited. As icons are provided with instructions (via dialogue boxes) the flowline is automatically amended appropriately (eg., -exit an interaction, continue, or try again).

In developing this strategy, the originator of Authorware, Dr Michael Allen, was impressed by the observation that designers, from a range of disciplines, created their work through successive approximations or iterations. He thus set out to create an authoring tool that would allow the same technique to be readily applied in creating CBL programs (Macromedia, n.d).

In their discussion of what authoring tool to use, Alessi & Trollip (1991) argue that just ease of use should not necessarily be a primary consideration - "it is of no benefit that a tool is easy to use if it does not do what you want" (p.346). The emphasis in debates over the relative merits of one system against another should focus on the capabilities of a given system to to allow authors to concentrate on refining the instructional design - the outcome as delivered to the student is what matters. Texts are beginning to appear (eg., Sims (in press)) which concentrate not so much on how to use a particular package or use a particular language, as on design-oriented procedures for developing effective interactional/instructional models, which can given effect with any one of the more sophisticated authoring tools currently available.

To assist in appreciating the possibilities of icon-oriented programs it may be of interest to note that the distributors of Authorware Professional and Icon Author have each made available a "Working Model" of their systems. These are 'training' versions of the full programs. They have restrictions (eg., on the number of icons allowed per file) but otherwise permit exploration of the critical @ Qdesign elements available in the full package. Teachers who currently use HyperCard as an authoring tool in secondary computing studies and who may wish to take student-authoring further may find good value in using a Working Model.

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CONSTRUCTING KNOWLEDGE AND ORGANIZING INFORMATION

BY MICHAEL JAY
Manager of Secondary Education for Apple Computer and past Education Technology Manager for the Apple Classroom of Tomorrow (ACOT).
and MARGE CAPPO
President of Learning in Motion

"When Computer Assisted Instruction emerged in the 1960's not enough research had been done to allow the design of program that would help students learn how to learn, learn how to set cognitive goals or to apply effective strategies for comprehension, self-monitoring or organization of knowledge. Although learning is what schools are designed to foster, classroom research indicates that knowledge and learning are not usually the focus of the classroom. Learning is only a by-product. This indirect approach to knowledge can work reasonably well, but it is poorly suited to the emerging information age, in which people are expected to work directly with knowledge."

TEACHERS AND STUDENTS AS LEARNERS

The ideal learning environment is one in which the teacher and the student are both learners. The classroom and the curriculum are shared responsibilities. Each should undergo continuous discussion and modification. The teacher should provide an environment that promotes interpersonal interaction, between between students as well as between teacher and student.

In order for this to happen, students should be prepared to be learners and be responsible for their own learning. Environments which encourage the development of independent and cooperative skills for students at all grade levels and across all subject areas should be encouraged. It is up to the teacher to create and support this kind of environment; it is up to the student to develop within that environment.

Technology can help create that environment. But the environment–not the technology–is the important factor.

THE TOOL-BASED ENVIRONMENT

A quote from researchers at the Ontario Institute for Studies in Education sums up the problem:

> "When Computer Assisted Instruction emerged in the 1960's not enough research had been done to allow the design of program that would help students learn how to learn, learn how to set cognitive goals or to apply effective strategies for comprehension, self-monitoring or organization of knowledge. Although learning is what schools are designed to foster, classroom research indicates that knowledge and learning are not usually the focus of the classroom. Learning is only a by-product. This indirect approach to knowledge can work reasonably well, but it is poorly suited to the emerging information age, in which people are expected to work directly with knowledge."

Young students have a natural curiosity. They seek knowledge and they want to understand 'why'. Sean Fahee is an example of such a child. Here is what Sean has to say:

> "My name is Sean Fahee. And I like dinosaurs. I am writing a report about dinosaurs on my computer at home. I really like dinosaurs so I thought...well...maybe if I run out of information I can use my own information like the old theories on new theories. Some of the new theories are: that the brontosaurus does not like swamps and dinosaurs were warm blooded. I don't know why scientist think that but they do think it. And also I thought maybe some day I'd start writing this book about space."

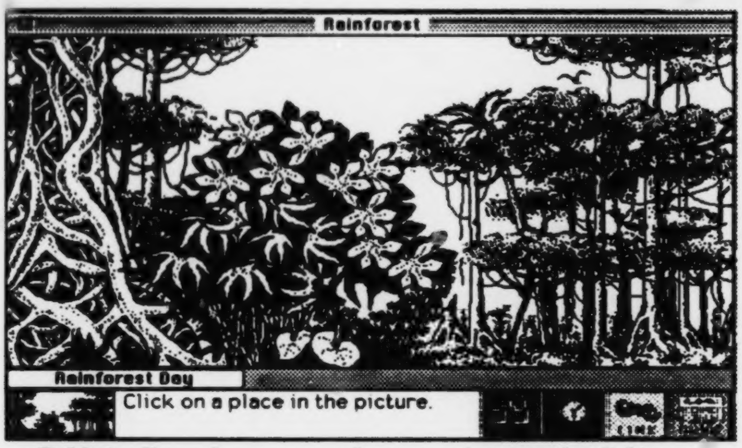
What characteristics do you see in Sean? What happens to Sean has he grows up? What happens to the question-asking, hypothesizing, consulting reference sources, explaining, criticizing and such? Why is it that children Sean's age, when asked "How does a light bulb work?" all raise their hands, even though they may have no clue as to the correct scientific answer; yet when you ask high school students the same question, they do not raise their hands because they are worried about finding the answer the teacher is looking for? What does our education system do to Sean's natural curiosity and search for knowledge?

A combination of content and organization of knowledge can provide a basis for a new approach to the classroom activities. Technology can help organize that knowledge and provide content. During the 80's, the application was the important part of the technology. In the 90's and the future, we see content and organization being the important factors to consider.

Many of the technology solutions today and more in the future, rely on engines and tools. Many of you have used a word processor. This is a perfect example of a tool. A word processor allows you–the user–to input, create, and organize your thoughts. It is only a tool; you must provide ideas.

A Fieldtrip to the Rainforest, a program described below, uses the concept of an engine. Rainforest can be thought of as a visual database which is available to the student. Other visual data bases can be 'run' on the same engine. Once an environment is learned, it carries through as a standard environment, which then becomes a tool for the students.

Once we standardize an environment, we can utilize it over and over again without having to relearn new interfaces. Many applications have the ability to understand documents created by a number of different applications. This puts the emphasis on the knowledge contained in the document not on the application that created it. Thus, the interconnection between content and process is the focus; the technology is there to support the evolution of those connections.



Click on a place in the picture.

Fieldtrip allows the user to explore an environment by clicking on sections of the Rainforest and gathering information.

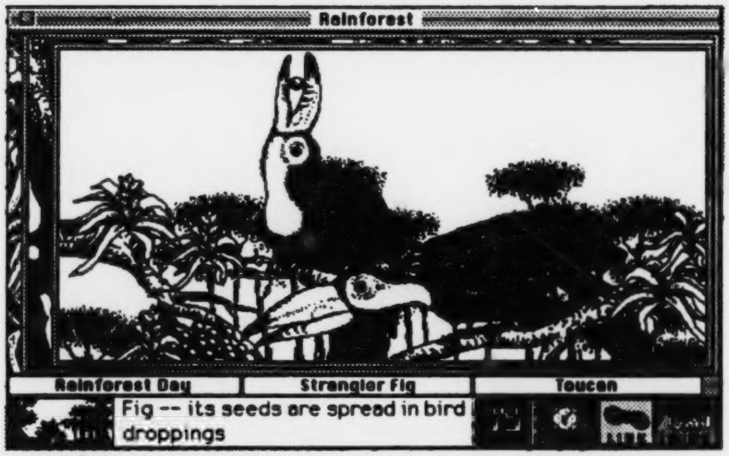


Fig -- its seeds are spread in bird droppings

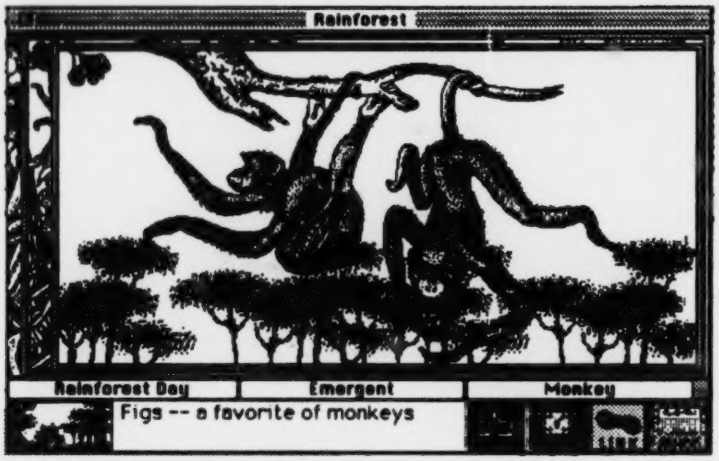
What can the students infer from this picture? The student can link to other animals that also eat figs.

There are technology features that will allow applications to 'talk' to each other and share information. When an application such as a word processor supports these communication features, the functions the student has already learned are accessible in other applications. There is no longer a need to learn a new environment to work with a word processor when one has already been learned. The student can focus on the content being written and not have to go through the process of learning a new tool.

GRAPHIC ENVIRONMENT TO SUPPORT EXPLORATION

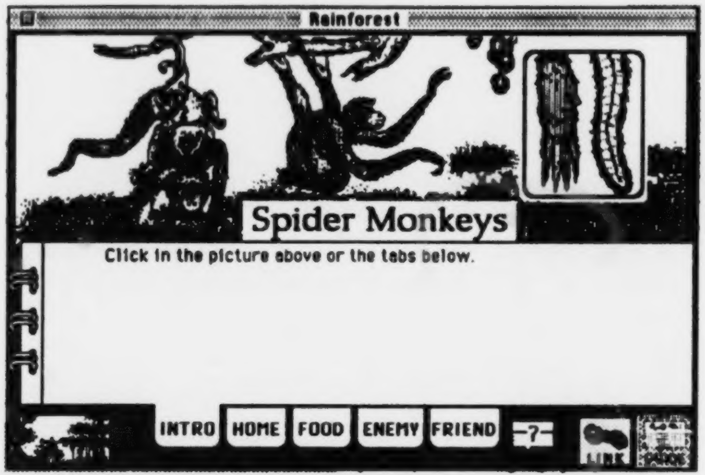
A powerful approach to education is to allow the student to step into an exploratory environment. As an example of this, we will use two programs to illustrate the construction of knowledge and then construction and organization systems to support that knowledge. Technology can support this approach through a graphic based environment which supports exploration and discovery. For the following example, two different pieces of software were utilized. The first is A Fieldtrip to the Rainforest. In this program, students explore a rainforest environment and discover the relationships between plants, animals and their surrounding environment.

With the next program, SemNet, students create their own semantic networks to organize and discover relationships in their findings. Even though these are two completely separate applications, we will be using them in tandem. We can use both programs simultaneously thereby using either program at any time.



Figs -- a favorite of monkeys

What can students say about a spider monkey and a toucan? Student can also explore more information on Spider Monkeys:

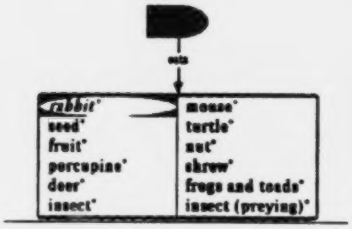


Click in the picture above or the tabs below.

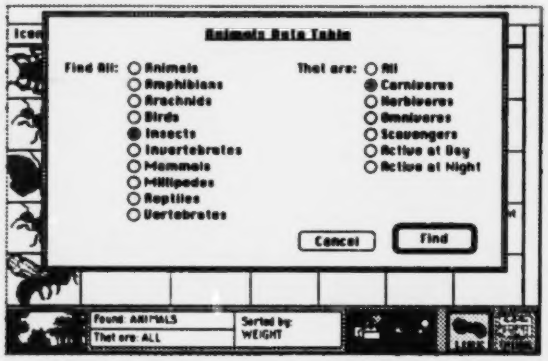
Fieldtrip allows the user to explore an environment by clicking on sections of the Rainforest and gathering information.

The other tool we're working with, SemNet, allows students to enter concepts and to discover relationships between those concepts - students can organize knowledge. This tool should be used in conjunction with other tools, engines or classroom work. Like a word processor or other tools, it is not a stand alone program. It needs to fit into the whole picture of learning environments and applications.

Students can work in pairs - but they could also work alone. The network illustrated below, allows them to make explicit the relationships between organisms. The current representation shown is built around the central concept "bear." The power here is that students are constructing their own learning environments and organizing their knowledge. Students have preconceptions of most anything they are working on. We tend to gloss over these in our teaching. Instead we just hand students facts and expect them to absorb them and place them within defined learning structures



rabbit*	mouse*
seed*	turtle*
fruit*	nut*
porcupine*	shrew*
deer*	frogs and toads*
insect*	insect (preying)*

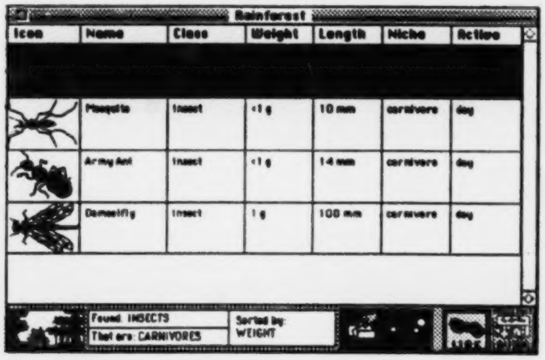


Animals Data Table

Find All:
○ Animals
○ Amphibians
○ Arachnids
○ Birds
● Insects
○ Invertebrates
○ Mammals
○ Millipedes
○ Reptiles
○ Vertebrates

That are:
○ All
● Carnivores
○ Herbivores
○ Omnivores
○ Scavengers
○ Active at Day
○ Active at Night

Found: ANIMALS
That are: ALL
Sorted by: WEIGHT



Icon	Name	Class	Weight	Length	Niche	Active
	Mosquito	insect	<1 g	10 mm	carnivore	day
	Army Ant	insect	<1 g	14 mm	carnivore	day
	Damselfly	insect	1 g	100 mm	carnivore	day

Found: INSECTS
That are: CARNIVORES
Sorted by: WEIGHT

Or explore a database which contains information on all the animals and plants in the Rainforest.

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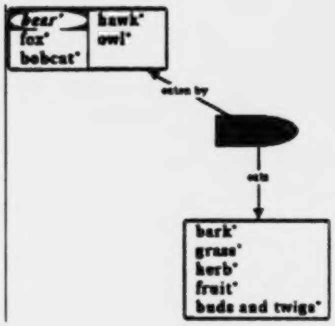
If you double click on one of the concepts in the network–the rabbit–that becomes the central concept. Relationships between concepts are of particular interest. We know the relationships that we want students to comprehend, but we need to allow room for discovery by the student. This process is critical and it takes time. It is important to allow enough time for the exploration of the relationships.


bear*
fox*
bobcat*
hawk*
owl*
eaten by
eats
bark*
grass*
herb*
fruit*
buds and twigs*

Of course the power of this tool lies in allowing students to create their own knowledge. We can combine Fieldtrip to the Rainforest and SemNet to create an environment where students can use one tool to organize the content explored and the knowledge gained in the other.

Students should be allowed to build and construct, not simply given the structure. The teacher is the guiding hand for the student to student interaction and asks pertinent questions to help the kids to further think of relationships in the semantic network.

The best learning occurs in children when they learn from discrepant events. 'Why is that happening? How can that be true?' When they begin to see discrepant events emerging, they can question the events. 'How can that be true if this is true?' Often the character of our conversations with students focuses on the low-level correction of content mistakes, therefore losing the opportunity for students to participate in the process of self-reflection on the structure of their knowledge.

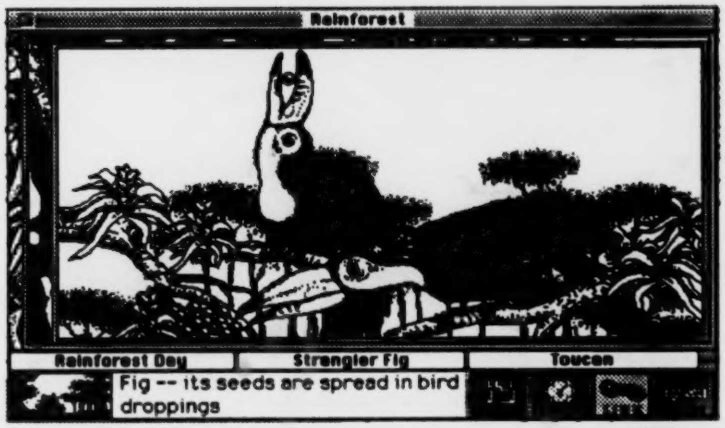
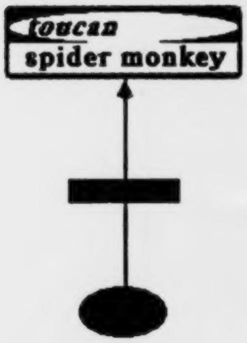
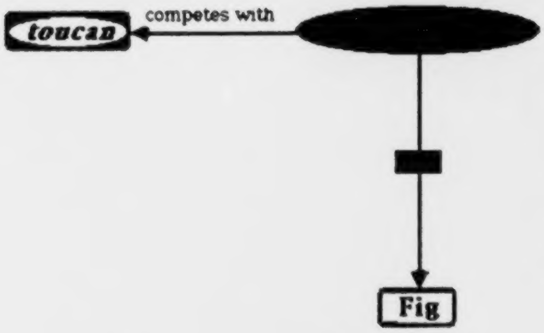

Rainforest
Rainforest Day
Strangler Fig
Toucan

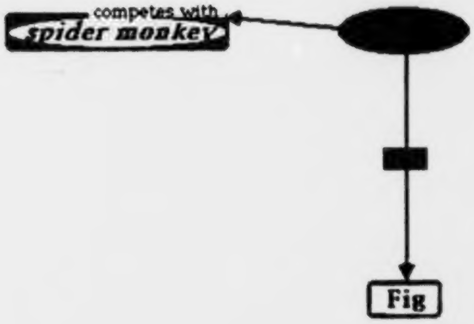
Fig -- its seeds are spread in bird droppings

Students can create a semantic network with their knowledge of the Toucan, the Fig, and the Spider Monkey.

These diagrams show how such a representation of the semantic network might loo


toucan
spider monkey


toucan
competes with
Fig


spider monkey
competes with
Fig

Scientists discover and question and organize information. A typical example of this scientific questioning and organization is illustrated in the interaction between Watson and Crick in the discovery of DNA, as portrayed in the movie *The Race for the Double Helix*.

Why DNA?

- Because it's there - doing nothing in every single living cell.
- While so far the gene is an entirely imaginary entity - a function without substance.
- DNA is a substance without function, a matrix. Ok; what's it made of? We know that it has phosphates and four bases.
- But what shape is it in all probability a helix.
- I buy helix.
- If a helix, how many chains.
- There has to be more than 1; the density measure tells us that.
- Yeah, but two, three....four?
- How do the pieces fit together - phosphates on the inside? bases on the inside?
- What does it do? Why doesn't it fall apart?

Our challenge: How can we, as teacher, keep that curiosity, that question-asking, that hypothesizing, that consulting reference sources, that explaining, and that criticizing in Sean Fahee as he grows up?

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SemNet, Kathleen M. Fisher, SemNet Research Group, 1043 University Avenue, Suite 215, San Diego, CA 92103-3392.

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Marge Cappo has an MA in Education from the University of Minnesota. She is President of Learning in Motion and has held positions of president of *WINGS for learning*, Vice President of Sunburst Communications; and Director of Development for the Minnesota Educational Computing Consortium. Marge has been a classroom math teacher and teacher trainer, and has designed and developed over 100 pieces of exemplary educational software.

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PREPARING PRIMARY TEACHERS FOR THE 21ST CENTURY

BY ANTHONY J. JONES
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The curriculum documents of most Australian states now include references to a variety of classroom applications for computers. In addition almost every primary school has acquired one or more computers for classroom use. However there are still problems with the provision of adequate computer related skills to both the existing teacher work force and to those undertaking initial teacher preparation courses. Both research and anecdotal evidence have revealed the ineffectiveness of short, one-off introductory educational computing courses at each of inservice and preservice levels.

This paper identifies computer applications and associated skills, for both teachers and learners, as contained in the various Frameworks curriculum documents published by the Victorian Ministry of Education, and briefly considers the implications that arise for providers of preservice primary teacher education. Finally, a model that integrates selected educational theory with appropriate hand-on activities is proposed.

INTRODUCTION

Selected aspects of educational computing have been taught as part of some Australian preservice teacher education courses for almost twenty years. For example at the First National Computer Education Conference (held at La Trobe University in May 1979) there was a "Forum on teacher education" in which three teacher educators described the objectives and content of the courses offered at their respective institutions. In each case the courses described had been running for some years. Since then papers relating to computers in teacher education have been delivered at all state, national and international educational computing conferences held in Australia.

As was also the case in schools, only specially selected groups of participants were involved in these early forays into educational computing for teachers. Invariably the content of such courses was based around programming, which reflected both the paucity of available software and the educational expectations of computing. Almost as invariable was the locating of this computing as part of mathematics. One specific example is the then Bendigo Teachers' College, where those students who elected to take a second or third year of mathematics were introduced to programming in BASIC through a range of numerical applications. It should be noted that the stated aim of the second and third year mathematics subjects was to broaden the mathematical background of participants, and so it was not considered necessary for this computing to have any relevance to what might occur in primary schools.

Computing in the school curriculum

Since the advent of microcomputers in Victorian schools ten or twelve years ago, teachers and students have discovered hundreds of potentially useful educational applications. Rather than attempt to generalise about current uses of computers in our schools I have elected to briefly mention where computing occurs in the Frameworks documents. By taking this approach I will deliberately ignore the only subject in Victoria specifically designed to teach about computing and computers - the VCE (years 11 and 12) Information Technology field of study.

Frameworks covers nine content areas and offers content, sequencing and teaching suggestions for the years Prep (first year of school, age 5) to 10 (fourth year of secondary school, last year that some areas are compulsory.) The Frameworks areas that explicitly mention computers are Technology Studies, Commerce, Mathematics, Language, Social Education and Science. In the section that follows the relationship between computing and each of these content areas is briefly described.

TECHNOLOGY STUDIES

... establishes technology studies as a new area of learning through reorientation and reorganisation of existing technical subjects, the addition of new knowledge, and increased emphasis on the processes of technological development in society. (The Technology Studies Framework 1988: 7)

While discussing the development of syllabi for technology studies, computers and computing is included as one of four areas of study. The three suggested orientations for computing are information technology (which incorporates word processing, data handling and simulation), control technology, and components of the computer.

COMMERCE

At primary school commerce issues are part of the total curriculum and students learn about financial issues in mathematics, keyboarding and information processing in language; and legal, economic and consumer issues in social or general studies. (The Commerce Framework 1987:78)

A major recommendation for primary schools is that computer keyboarding should be taught in an organised form beginning in year three. Noting that keyboarding in primary schools is often taught as part of English language studies, the following skills are listed:

- operating an alphanumeric keypad
- keyboarding techniques
- basic text editing and formatting
- storage nd filing
- disks
- hard copy
- basic ergonomic principles
- computer
- hardware
- software
- basic operations

MATHEMATICS

Computers have a great potential for improving the teaching of mathematics. (The Mathematics Framework 1988: 38)

One chapter, approximately ten pages, is devoted to applications of calculators and computers in the mathematics curriculum. However there are no real guidelines for teachers on how to start integrating computer use into their teaching, and the scope and sequence chart for content does not mention computers (although Logo is named once.)

LANGUAGE

The use of word-processing equipment is leading to a radical transformation in the way people approach writing tasks.

(The English Language Framework 1988: 15)

Word-processing equipment should be available to enable students to revise and redraft their writing easily and to facilitate collaborative writing and group work.

(The English Language Framework 1988: 31)

SOCIAL EDUCATION

Communication and media, together with technology, are among the content themes suggested for primary school use. In general the approach in social education does not involve students in hands-on operations with computer hardware and software, although there are applications in word processing and simulations.

SCIENCE

While computers are mentioned as part of an overview of content at various levels, the major reference to them is in the area of resources. Here computers are categorised as being a:

- tool for students
- word processing
- data collection
- data processing
- teaching aid
- simulate
- provide and manipulate data bases
- enable students to solve problems
- tool for teachers
- word processing
- sharing information between schools
- records and data bases

(The Science Framework 1988: 74)

Collating the information from the various frameworks documents provides a list that includes:

- keyboarding
- computers components
- operation
- control technology
- word processing
- information management
- social issues
- software use
- word processor
- data base
- spreadsheet
- Logo
- simulation
- problem solving

Computing in preservice education

Preservice education for teachers must be seen as an initial preparation for the first year or two of classroom teaching. Because of the extra-ordinarily diverse range of situations teachers can be appointed to, it is impossible to provide the experiences, simulations, or even knowledge to enable beginning teachers to be fully prepared for what ever circumstance they find themselves in.

This is equally true in the area of educational computing. Even though statewide curriculum definitions such as the Frameworks documents exist, there is no guarantee that school A will approach a particular topic in similar or compatible ways to school B. Of greater concern to many teacher education students and lecturers are the tremendous dissimilarities in computer hardware between various schools. Such concerns reflect the increasing tendency to train student teachers in the use individual pieces of software rather than to educate them in the concepts and applications of a software genre. As an example consider word processing. The temptation for many teacher educators, and consequently the practice in too many preservice courses, is to train students to become competent users of one package.

At one level, a quite low level from a cognitive point of view, the aim of teacher education students becoming competent personal users of a word processing program is justifiable. However prospective teachers need to go considerably further than this; they must analyse and evaluate what they have learned and then synthesise the various components of word processing into learning experiences suitable for the classroom. To only train teachers to use word processing for personal use is metaphorically similar to concentrating solely on grade three during a preservice course. The latter idea would not be countenanced because we prepare teachers to teach at all levels over a six or seven year range. Why then should preservice teachers be taught only to use computers for personal use?

Historically the use of computers in preservice teacher education courses has tended to mirror what has occurred in schools. Ten years ago secondary school computing courses emphasised programming. Those primary preservice teacher education courses that offered computing units also concentrated on programming. There are two criticisms that should be made of this strategy. The first is that it was a form of "catch up" education; it was reactive rather than proactive. Surely teacher education courses should prepare teachers for the future and not just for the present. The second criticism relates to the almost universal practice of concentrating solely on the development of personal proficiency in the operation of hardware and software. This meant that issues of classroom management, curriculum change and teaching strategies were neglected.

Skills, concepts and experiences for preservice teacher education course.

First it must be recognised that there are two aspects to computer education in the preservice teacher education area. Initially there is the acquisition of personal skills and proficiency in the operation of hardware and the use of software. The second, and major, aspect is to build upon these personal skills to enable classroom teachers to provide appropriate learning experiences for students. In several ways this is considerably more difficult in a preservice course than is the acquisition of personal computing skills.

In the subjects that teacher education students will be expected to teach (language, mathematics, etc) this is either built into the preservice course (concurrent courses) or is a prerequisite (end-on courses). Once students have sufficient subject knowledge then teaching methods, curriculum design and other appropriate classroom skills can be developed. Educational computing should be treated in exactly the same way. However, as has been suggested previously, the majority of teacher education courses appear to cater only for the development of personal skills.

A paradigm for preservice computing

This proposal is put forward as a paradigm rather than as a curriculum or an example because it is more appropriate to consider it as a multi-faceted structure that has greater explicitness than either a metaphor or analogy but less prescription than a model or exemplary case study. The purpose of the structure is to provide support for teacher education students to undergo cognitive, affective and pedagogic experiences, to make conjectures and to reflect on personal and peer learning developments.

In the description and discussion that follow there are several references to computer applications in preservice mathematics education. This is inevitable because the initial experiments in developing the paradigm took place in preservice mathematics education courses. However the paradigm has application in many content areas and with a wide range of software.

The constituent elements of the paradigm are : -a constructivist approach to learning; a Logo-like learning environment;a problem-based curriculum model; clear links made between content, software, and the world; explicit use of software for content and pedagogy; implicit use for philosophy. Due to a lack of time and space not all of these elements will be described in detail in this paper.

CONSTRUCTIVIST LEARNING

Knowledge cannot start from nothing - from a tabula rasa - nor yet from observation. The advance of knowledge consists, mainly, in the modification of earlier knowledge. (Popper 1974: 28)

Within the overall structure that will be described in the following components of the paradigm, the teacher is guided by the principles of the constructivist theory of learning. In particular the concept of learners being active participants in the learning process, rather than passive recipients, is presented overtly through a variety of means. These include modelling by the teacher, reflection by participants on how and what they have learned, and group discussions of the teacher's modelling and individual reflections.

Another important aspect of constructivist theory is the belief that learners construct new knowledge by building on to existing knowledge. It becomes necessary then for the teacher to be acutely aware of the current state of each learner's knowledge. Given that a formal pre-test would not be considered appropriate in a Logo-like learning environment, other methods such as teacher observation of students at work, examination of work produced, and discussion between learner and teacher must be employed.

The Logo-like learning environment

This element of the paradigm pays special attention to the aggregate of all surroundings and influences that support the learning process. Teachers often learn Logo in physical surroundings, through pedagogic approaches and in cognitive contexts that are vastly different to those suggested and implied by Papert in Mindstorms. Researchers from the Israeli Logo Centre comment:

> *... teaching Logo properly is a non-trivial task, requiring careful preparation. In many cases we have observed, teachers were introduced to Logo by the local computer expert ... [These] teachers tended to have an impoverished view of Logo. They often taught Logo merely as a programming language for kids, neglecting the broader educational spirit of Logo and the deeper ideas behind the programming activity. In the more extreme cases, syntax reigned and the fun and creativity were all but gone.* (Leron and Krumholtz 1986: 226)

Designers of inservice educational computing courses then are faced with the dilemma resulting from teachers wanting to learn in one manner and teach to their students in a quite different manner. Teachers at inservice courses tend to want to be given factual information and activities that are ready for classroom use rather than to expend time and effort exploring Logo for themselves. The establishing of an appropriate learning environment for an inservice course is often regarded as unnecessary and even an impediment to what teachers really need.

In a seminal article Riordon (1982) defines a Logo environment as:
... the entire context, made possible and managed by the teacher, in which students work with Logo. It is more than a computer learning station. It includes psychological as well as physical space - how students feel, how students and adults interact. (Riordon 1982: 46)

He then describes a Logo classroom over a teaching day, reporting major characteristics. One feature is the provision of opportunities for students to demonstrate procedures they have been working on, and a following discussion based around four questions:

1) Do any class members have questions about the procedure we've watched?
2) What do you plan to do with your procedure now?
3) Do you have some ideas to try out or do you need some hints about how to do it?
4) What are some things that could be done to change this program?

(Riordon 1982:47)

At the end of this section Riordon concludes that the teacher is responsive to the level of student frustration, has in mind a sequence of Logo programming concepts and a large repertoire of Logo project ideas, and encourages students to discover solutions to problems by reflecting and conjecturing about what they are doing.

A Logo environment has many of the attributes of a democratic classroom. Authority is distributed; sharing and cooperation are promoted; students look to their classmates as legitimate sources of information; because students make project choices, variety rather than uniformity is the norm; rewards are intrinsic; differences in working style are valued. There is a sense of shared learning - students may hear their teachers respond, "I'm not sure how to make the computer do that. I'll work on it at home tonight." (Riordon 1982: 48)

A range of features that are noticeably not present in Logo environments are then discussed. Included among the absent features are projects set by the teacher for the whole class to attempt, and formal evaluation of student learning.

In discussing reasons for setting up a Logo learning environment, Riordon refers the reader back to the fundamental concepts of Logo that Papert expounded in Mindstorms, especially the belief that children can learn much without having formal instruction imposed on the learning process.

Providing opportunities and encouragement for learners to reflect on what they have done, how they have thought about the problem they are working on, and what they perceive they have learned is an inherent feature of Logo learning environments. Papert has made many references to children thinking about their thinking and notes that Piaget has emphasized the importance for intellectual growth of children's ability to reflect on their own thinking. (Papert 1980: 169)

Reflection is also important for teacher education students as they juxtapose the conflicting roles of learner and teacher. One researcher who has studied the role and practice of reflection among professional people, including teachers, is Donald Schon. Schon (1983, 1987) argues for a new epistemology of professional practice that starts from the competence and artistry already a part of the skills of a proficient practitioner. In particular Schon focuses on reflection-in-action (thinking about what they are doing while they are doing it.) Schon 1987: xi) For the teacher this means first taking note of what students say and ask, and then reflecting on these statements and questions.

The teachers are astonished by the sense behind a student's mistake. ... *the practitioner allows himself to experience surprise, puzzlement, or confusion in a situation which he finds uncertain or unique. He reflects on the phenomena before him, and on prior understandings which have been implicit in his behavior.*
(Schon 1983: 68)

Schon believes that many professional practitioners, including teachers,locked into a view of themselves as technical experts, find nothing in the world of practice to occasion reflection. (Schon 1983: 69) He summarises differences between experts and reflective practitioners in the following way:
(Schon 1983: 300)

For teachers and teacher education students the lessons to be learned from Schon's work include the necessity to listen to and heed what learners have to say, the importance of teachers being part of the learning process by becoming learners as well as teachers, and for the continuing need to reflect on classroom incidents and the behavior of all the participants. All of these factors complement Riordon's (1982) description of a Logo learning environment.

In relation to the role of computers Schon comments that, *[a] reflective teacher needs a kind of educational technology which does more than extend her capacity to administer drill and practice. Most interesting to her is an educational technology which helps students to become aware of their own intuitive understandings, to fall into cognitive confusions and explore new directions of understanding and action.* (Schon 1983: 333)

THE CURRICULUM MODEL

The preferred curriculum model emphasises the role of the teacher. However this does not mean that the curriculum is completely teacher directed or centred. The teacher is at the centre of this model because of the belief that effective learning is a consequence of the teacher providing both appropriate activities and a suitable learning environment. In this paradigm the milieu for learning is the previously described Logo-like environment.

Schematically the curriculum representation consists of four concentric circles or layers and is an adaption of the a design suggested by Taylor (1980). The kernel or innermost layer is the teacher. It is the teacher's duty to prepare a range of problems for the learners. These problems, which constitute the second layer, are carefully selected according to their content, context and appropriateness for the learners. The teacher uses personal knowledge of the learners and the content material to determine how focused the statement of the problem will be. At times it will be appropriate to present a theme with the expectation that learners will develop their own projects and pose their own questions within this thematic framework. In many classes some learners will require a more specific statement of the problem. For some learners this still might not be suitable, and so the teacher could find it necessary to provide even more direction. This could be accomplished through the use of a microworld for the learner to explore or through the learner commencing a project in conjunction with the teacher or a peer.

Problems provided by the teacher specify the content of the curriculum and in the course of their solution will introduce learners to a range of ideas. It is much more difficult to define in advance the ideas that learners will meet as they attempt to solve problems. These ideas constitute the third layer in Taylor's curriculum model. It is quite possible that many of these ideas will remain implicit while learners work on the problems.

The outermost layer of this model contains techniques. While the techniques arise from ideas generated in solving problems, the techniques enable the ideas to be concentrated, formalised and generalised to the solution of other problems. Because they are more general than either ideas or problems, the techniques can help establish links between the problem being solved and the rest of the world.

Teachers must facilitate the process of engaging all learners in an activity that they are willing to "own" on a personal level. While ownership of a problem is important, it is also crucial that the sharing and publication of work done be an integral part of the learning process. Sharing involves more than just displaying an end product. Ideally there should be peer discussion and interaction throughout a project. Even at the beginning of a project, while the it is still largely in the conceptual stage, learners can be encouraged to discuss their ideas and expectations openly with peers and teacher.

CONCLUSION

Every year the number of computers in schools increases. At the same time the number and scope of computer applications within the primary curriculum is enlarged. Computer education has been part of most primary inservice teacher education courses for several years. However there is a significant difference between training teacher education students to use particular pieces of software and preparing them to make effective use of computers in a classroom context.

This paper has proposed first that preservice computer application should be strongly aligned with primary school subject areas and not be taught in isolation, and second that a paradigm encompassing constructivist learning, an exploratory learning environment founded on a curriculum that engages learners in realistic problem solving activities and establishes links beyond the classroom is an appropriate and effective model. Use of this paradigm has enabled preservice teacher education students in the areas of humanities, mathematics and primary to develop understandings and skills that increase their utilisation of computer hardware and software in the classroom.

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ELECTRONIC COMMUNICATION IN SUPPORT OF TEACHERS

BY ROS KEEP

Publicity Officer for the Educational Computing Association of Western Australia, Account Manager of the ECAWA NEXUS account and joint co-ordinator of the HealthLines project. She currently works as Educational Consultant at the AppleCentre in Perth.

Many teachers the world over feel isolated in their classrooms. This may be due to geographical location, through teaching in specialised subject areas; even in large urban schools where teachers rarely have the chance to come together and share experiences and views. A feeling of isolation may also come from being out of touch with current educational initiatives and trends. Many teachers feel 'tied' to their classrooms and cannot attend as many professional development sessions as they would like. Furthermore, they have little time to read educational journals or wade through research findings even where they are accessible.

The 'Information Revolution' has done little to improve the teachers' lot: there is ever more information available, but little opportunity to peruse it. And yet they need further information. A recent study in the UK (Marshall & Keep, 1991) has shown the range of information required by teachers and the difficulties of getting the information to those that need it. This was particularly worrying with the recent 'educational revolution' in which the National Curriculum was implemented and schools became more concerned with their own management. Electronic communication was offered as a possible solution.

This paper describes an initiative taking place in Western Australia which aims to reduce teacher isolation and encourage and enable them to work together.

INTRODUCTION

The Educational Computing Association of Western Australia has a membership of around 240 individuals and schools. Like other teacher associations, it aims to provide information for its members to support them in their role as educators. This is done primarily by a regular magazine, Login, but also through courses, conferences and camps. However, as more than 70% of the teaching population is in the metropolitan area, most of the events organised by the association take place in Perth. Country members have no opportunity to attend evening workshops and presentations, find it difficult - and expensive - to attend weekend camps and even the annual conference may cause problems for those who live in the far reaches of the State. Due to the particular problems of WA with respect to the size of the state and the distance between schools, the feelings of isolation described above are even more prevalent here and many teachers may even feel abandoned, particularly in their first years of teaching.

In looking at ways in which ECAWA could better serve its membership, one suggestion was the use of electronic communication. The very nature of the ECAWA membership ensures that all members have an interest in using computers, the majority have easy access to them and some level of expertise in this area. A number of committee members also had some experience of using telecommunications. It was therefore decided to trial the use of an electronic communications service as a means of disseminating information to the membership and encouraging communication between members and committee members. After looking briefly at the services available, NEXUS was deemed the most appropriate for the task.

NEXUS is an electronic communications service established and developed in South Australia especially for education. It offers electronic mail, where individuals can send messages to others individually or through distribution lists; bulletin boards, where users can add messages for a wider audience; and databases, either those provided by others for reading and searching or developing databases where readers can add their own information.

Databases and bulletin boards can be public or restricted to particular subscribers to the system. Its major advantage over other services, however, is the method of payment. Unlike most other systems, there is no joining fee: subscribers simply pay for what they use. This has enabled the ECAWA committee to provide a specific fund for each member which can be used entirely to cover the on-line costs of participants. The costs include both Austpac and Nexus' own charge. The user pays only the cost of the local (timed) telephone call.

Another key feature of the system is the ease of account management. An account manager can restrict access to particular portions of the system (such as the ECAWA databases); specify the times and days of access; tailor the main menu to include only those options which will be most useful to users; and most importantly, to monitor the usage of the system by individuals. It was decided that each member would be given twenty dollars free use of the system. This would provide enough access time to

- get a flavour for the service and see what it offers with a view to taking their own subscription;
- show other teachers its potential for their curriculum area; and
- allow members to collect any information which ECAWA disseminated via this method, even if the school or individual did not decide to take their own subscription

IMPLEMENTATION

The majority of members were already at least aware of the existence of electronic communication systems, and, with presentations at earlier conferences, some had considered the potential both for their own use and within the curriculum. At ECAWA's state conference in June 1992, the membership as a whole were further introduced to the idea of electronic communication through a keynote address by Ralph Leonard, the manager of the NEXUS system. The presentation went into some detail on how to use the system and showed many of its features.

In July 1992, every member of ECAWA was provided with a subscription to NEXUS in their own name, in the case of individual members, in the name of the specified contact person for institutional members or in the name of the school. Members' accounts were given 'ECAWA' status, and this does not change if members take their own personal or school subscriptions. In this way, they continue to have access to ECAWA information even when no longer using the ECAWA account.

Two bulletin boards were immediately set up: the first was for ECAWA members to log their own details and interests so that others could see who was active on the system and perhaps find people with similar interests. The second board was for general 'Chat', a forum in which members could discuss issues, make comments and ask questions of others. Both these boards were set up for access by ECAWA members only.

In September 1992, a third board was added. This was an 'Events' board, which aimed to provide information to anyone, ECAWA members or not, on events in WA which included at least an element of computer-related information. The board can have information added by any person. With the fields specified, it should be possible for teachers to search the board for events which use a particular hardware platform, or are aimed at a specific age range or curriculum area.

Late in November the first 'online Professional Development' session was implemented. The chosen topic was the Technology Statement, as the interim document had recently been released. This board was for ECAWA members only.

EARLY EXPERIENCES

(Figures given here are to the end of January 1993)

Usage: Around 35 schools in WA were already subscribers to the NEXUS system, but where these were also ECAWA members, they were simply given a new account which was deemed for ECAWA use. One of the most useful facilities of NEXUS is the ability to set up more than one account for a subscriber, each with different funds and different usage parameters if required, but with the same mailbox access. This means that no matter which account is being used, all mail is accessible.

At the end of January 1993, the ECAWA account contained 241 subaccounts. Around 45 of these have used their NEXUS subscriptions. This represents less than 20% of the membership. Of these, twenty one have have subscribed in their own right.

Bulletin boards: Members have shown varied interest in the bulletin boards. The Members database has only 19 entries, but statistics show that it has been read by 29 users with over 130 accesses. It is clearly of interest to the membership, so why have so few people entered their details? This may be fear of 'going public'; or it may be because the user is not actually an ECAWA member and therefore feels something of a fraud!

The Chat board has been read by 26 members, but less than half have contributed. The phenomena of 'lurkers' - those that read but don't write - has been documented elsewhere (Keep, 1991; Mason, 1989) and is of no surprise.

The Events database has been less successful to date with only the Account Manager having entered details and only 13 readers. It seems that individuals - even other committee members - are not inclined to enter information. It may be that one person needs to be designated to keep this board 'live'.

The Technology Statement board was probably set up at exactly the wrong time of year - late November. Most teachers were in the throes of writing reports, involved in end of term activities, consolidating their records or preparing to change schools. Nevertheless, a few people have contributed to the board and 12 different users have accessed it. It was suggested that, because we could guarantee more 'listeners' than 'speakers', members of the committee could help by asking questions or making comments which they felt would be useful to others.

EMail: The use of electronic mail is harder to gauge as no statistics are available. However, with the availability of distribution lists, it is a simple matter to send a message to all ECAWA members simultaneously. A number of such communications have been made: this method was used, for example, to inform the membership of new bulletin boards, email projects which were taking place around Australia and to remind people of the forthcoming ECAWA AGM. The main drawback of such messages on NEXUS is that those which are not read by the recipient are 'returned to sender' - which is very useful so the sender knows who hasn't received a message, but something of a chore when there are almost 200 returned messages!

Committee usage has not been as high as it might have been. The use of NEXUS between Committee meetings could be a useful method of keeping in touch, 'tabling' papers which are to be discussed at a future meeting, preparing the agenda of meetings and circulating minutes. Not only will it save time by making information available almost immediately, but also will save money on postage, stationery and the time taken to photocopy, collate and post out information to other members. What's more, it provides a simple method of keeping the membership informed of the discussion and decisions of the committee. As ECAWA's secretary did not have access to a modem through 1992, this aspect has not yet been explored.

***Login* articles**: In an effort to keep non-NEXUS using members abreast of developments on the system, a regular article is submitted into the association's magazine. It is recognised that when the project was initiated, many members did not have access to a modem or telephone line; however, some schools may now have acquired the facilities or perhaps members have moved to another school which does have the equipment, and so it is important to keep the concept of NEXUS to the fore.

Problems: Although it is too early as yet to send out questionnaires to members to gather definite information, it is likely that the one of the main obstacles to use is the lack of either the modem or the telephone line. In the UK, where a government initiative put modems into all schools who requested one, this was closely followed by funds to put in a new telephone line for online work. Without a similar project here, it is unlikely that we shall see all schools having equal access to electronic systems. The problem is particularly true in primary schools: it is noted that of the 45 NEXUS users, only a couple are in primary schools.

Although NEXUS itself is easy to use, there have been many problems with actually gaining access to the system. Schools use such a divergent range of equipment and software, it is impossible to write guidelines to help first time users. Problems have arisen at every step: some have had problems with their telephone system; others with the hardware; and others still with the their choice of communications software. Luckily, few users have had more than one problem to overcome!

Once into the system, problems become fewer. However, the one which recurs most frequently comes from more 'advanced' users who try to send text files. Some communications software seems to handle this badly and this had led to some frustration.

Earlier research (Bull et al, 1989) has shown the need for a certain 'critical mass' of users on a network who use the system on a regular basis. ECAWA tried to achieve this by implementing this project and giving all members access from the same date. However, because few people were immediately active - and vociferous! - it is debateable whether this critical mass has yet been achieved. The lack of immediate use may be attributed to a lack of focus for communication. This has been found to be essential in the successful implementation of student links (Keep, 1991). The HealthLines project, funded by Healthway, is the first curriculum-based project to be run in WA with a view to showing the potential of email for curriculum and student use, and it is hoped that this project will encourage more teachers to use the system.

The enthusiasm of the organisers has been found to play an important part in developing and maintaining an 'online community' (Mason, 1989; Sunal, 1991). The Account Manager should maintain a high profile on the system, offering assistance and support to users in a friendly non-technical way. However, as with most committee members of such an organisation, the Account Manager has limited time. The Account Manager goes online most weekday evenings to answer mail messages and devotes some time to the collection of usage statistics for committee meetings, but always more time could be spent in maintaining and developing the bulletin boards or in direct communication with members.

FUTURE PLANS

There is, unfortunately, little that can be done for those members who cannot access NEXUS because they do not have the facilities - modem and telephone line in particular. There is however, one state-wide initiative which may help, and that is the automation of libraries. A number of schools are currently involved in the process, and some of these have already opted to include a modem for online access to central records. Where there is a modem, there will be a dedicated telephone line. This initiative may well be responsible in the future for boosting members' access. Another possible approach might be for ECAWA to obtain a number of modems which can be loaned out to members on request, even for use at home. If members can then show their colleagues the potential of electronic communication, it may become a higher priority within the school.

There are a number of possible strategies for increasing the value of the system amongst those who have access. The following are likely to be trialled in the short term:

- more committee business to be conducted online
- the posting of the minutes of committee meetings into the 'Chat' board for general discussion
- a 'revitalisation' of the Events board, probably by designating another committee member to its management
- further curriculum projects like HealthLines: this is likely to include a 'Newspaper Day' where students collect and write stories for a newspaper which are assembled using a desk top publishing program all in one day and then submitted in a competition
- further 'online professional development' sessions - perhaps even something on how to run a Newspaper Day in a school!

CONCLUSION

Although the project has not been overwhelmingly successful in terms of numbers, this was not totally unexpected. Previous studies have shown that even where users are provided with free mailboxes and already have all the equipment necessary for communication, there are many who either never use the system, use it infrequently, or only at the start of the project (Mason, 1989). However, the main objective is to improve the service ECAWA offers to its membership, particularly those in country areas and if only one quarter of the membership uses the facility, it is likely that those members will feel a closer involvement in their association, have improved links with others and have extended their available information sources.

We clearly haven't solved the problem of teacher isolation yet, but this project could have far-reaching consequences, not only here in WA but across the country and even around the world. The idea of providing 'electronic support' for teachers has been discussed in different countries by teachers, researchers and information providers, but in many cases the services available are too costly, too unfriendly or not designed for educational use. NEXUS is a service which allows this kind of experiment. If successful, such systems may be employed more widely as a cost-effective method of disseminating information; to enrich, expand and sometimes to enable the professional development of teachers; and as a new vehicle for teacher-support networks which may build the confidence of teachers and improve teaching and learning experiences in schools.

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CURRENT PRE-SERVICE TEACHER EDUCATION: HANDICAPPING THE COMPUTER, THE TEACHER AND THE STUDENT!

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Ever increasing demands by in-service teachers for computing subjects highlights the need for Schools of Education to focus on the development of a more in-depth Computers in Education Curriculum. This paper makes an hypothetical comparison of the old to the new, by using an analogy of the introduction of (new technology for the times) chalk-n-talk as a comparison to computers in education using Hypertext and Authoring software as the modern counterpart. By using a little imagination one could replace the use of chalk-n-talk with the use of computers.

Current research reflects in general the prevailing lack of emphases in existing educational computing curriculum in contrast to what is felt to be advisable by those teaching the subject. To further complicate the issue the National K-12 Curriculum indicates the growing necessity for educators to gain more expertise in technology that has yet to be addressed.

This paper argues that the introduction of Hypermedia into the curriculum will enhance education by responding to market forces. The market in this instance is the body of educators in pre-service training, practising pre-tertiary educators and in many cases, tertiary educators themselves. This market is clearly stating that they are dissatisfied with the level of competency resulting from existing teacher training courses in technology.

INTRODUCTION

Current Pre-service Teacher Education rarely produces teachers that are adequately prepared to make full use of the computer as an educational tool. Generally, the level of computer expertise reaches a level described by Duckett as"...the ability to set up equipment, load the system and application software used and demonstrate the ability to use at least one application at a level that requires no outside help." (Duckett 1992 p. 92)

This paper suggests that current developments in educational software have reached the stage where Pre-service Teacher Education (PTE) ought to include at least, a basic introduction in the use of HyperCard as both a hypertext educational package and as an authoring tool for educational courseware production or adaptation. If adopted this would produce graduates reaching a level of expertise usually expected only in post-graduate students who have completed further study. The level of computer literacy achieved would approximate with Specialised Developmental or Computing Issues as described by Duckett to a Level 4 competency:

"...requires the ability to use a library of software of at least three applications at a level that requires no outside help. should have the:

- knowledge and ability to use a computer network and E-mail,
- ability to use an authoring software package or other [specialised] off the shelf software. [e.g. statistical or high level programming]
- has a well developed understanding of:
    - the influence of computers on everyday life
    - the legal implications of software copyright
    - the use of computers and software in the curriculum.

(Duckett 1992 pp. 92-93)

For arguments sake let's make a comparison using an old technology analogy of chalk-and-talk.

Imagine the scene in a teacher training institution when the use of blackboard and chalk were new technology. Of course, those teaching the future teachers would have become intimate with blackboard and chalk technology and the skills essential to use it successfully - skills ensuring that the board was positioned in such a way that all could see and textual material was large enough so that those seated at the furthermost point could view it clearly without straining.

Graphics (pictures, diagrams etc.) would be traced carefully from specially prepared originals made by qualified artists (being deemed that the untrained would not be capable of producing material of sufficient quality since it would take too much time). Restraint would be used in the use of fancy features such as excessive use of colour chalk and inappropriate use of variation of writing styles (e.g. printing versus hand-writing).
The number of panels in use at any one time and the speed of delivery of new material, before erasure of the old, would be subject to strict guidelines. Acolytes would learn, the ratio of the size of the writing to the size of the available space must fit within prescribed parameters.

The number of panels in use at any one time would be three, allowing pupils to copy from the previous two while the third was being prepared or erased, ready to use for new material.

Such was the level of skill required for effective use of the blackboard and chalk there may have been some controversy over whether or not a beginning teacher might best make use of approved texts, containing all the blackboard layouts necessary for any conceivable lesson, rather than make some sort of amateurish attempt of their own. (Enterprising scholars would have published excellent books containing brilliant blackboard layouts, complete with traceable diagrams for everything from Greek grammar to Euclidean geometry.)

There would undoubtedly have been murmurings of discontent from several practitioners about the lack of flexibility in these pre-prepared collections. Increasing numbers of practitioners would have been openly advocating that teachers should be given greater freedom to develop their own material and some, even attempting it.

However, mainstream opinion held that this blackboard technology was educationally valuable, here to stay, and therefore ought to be taught to all potential teachers. Those skills deemed too advanced for undergraduates (such as preparing blackboard illustrations) were conveniently labelled the domain of other professions, such as that of artists, and left to optional post-graduate studies.

Fictional as this scenario might be, a comparable situation appears in many of the tertiary institutions now, preparing teachers with regard to the use of computers. Pre-service Teachers are taught how to use computers in what could be described as a limited fashion only. That indicates, the computer as well as the prospective teacher is effectively handicapped. Therefore the full potential of the computer or the educators use of it is not taken advantage of. In general, teacher's computer preparedness, at best, consists of learning how to use the computer:

1. as a tool to improve their own productivity, i.e. as a word processor to prepare notes, tests, etc., as a spreadsheet to keep track of student assessment or department budgets or even attendance records or a database manager to keep track of student and staff details such as timetable information.
2. as an instrument for the delivery of learning material in the form of educational software to students.
3. as a means to motivate students to improve their productivity in much the same way they have, themselves, improved their own productivity. (e.g. Word-processing, spreadsheets and databases)

Duckett's yet to be published research, taken from a 1992 survey of 21 Schools of Education in Australia, reflects in the table on the following page, an average of the current trend of emphasis, as applied to the pre-service teacher's computer preparedness of the aforementioned subjects discussed above.

The information contained in the table is derived, based on item three of the Issues, as described by Duckett, in the Focus Of The Study in Appendix A.

The key for the table is:
1 = No emphasis 2 = A little emphasis 3 = Moderate emphasis 4 = Strong emphasis

	% Current Emphases				% Preferred Emphases			
	1	2	3	4	1	2	3	4
Word-processing, Database, Spreadsheet (productivity tools)	6	25	38	31	0	0	50	50
Computers as an administrative tool.	31	50	13	6	6	25	56	13
Use of authoring software.	56	25	19	0	13	31	44	13
High level computer programming languages.	19	25	38	19	0	31	50	19
The use of Computer Assisted Instruction.	44	25	19	13	13	44	19	25
The use of Computer Managed Instruction.	50	50	0	0	13	50	39	0

Duckett's research focuses on the development of a model curriculum for CIE. The curriculum is to be designed so that it reflects a good balance between the theoretical and practical approaches to the teaching of CIE.

The above table reflects how the subjects are currently taught as opposed to how lecturers would prefer to see them. The precise mix of these varies depending on location to a greater or lesser extent. Research indicates computers are generally taught in a very limited fashion.

The computer's most valuable virtue is its ability to be used in a variety of ways as no other tool invented ever has. It is precisely this potential for flexibility that is being withheld from pre-service teachers, effectively handicapping them in their role as educators!

In a few institutions, undergraduate students are given an introduction to the use of authoring languages (software designed to allow users to create software without requiring them to perform actual programming) but very few, if any, go so far as to recommend that teachers should seriously consider using the computer to produce their own educational material.

This is not dissimilar to telling students that they may only use the blackboard and pre-prepared blackboard material to teach but they may not develop their own. It is hazardous to carry the analogy too far however; it would appear that student teachers find themselves generally unprepared to make full use of computers. (Wilson 1990, p. 162)

The implications for teacher training institutions are important and some questions arise as to what response these institutions ought to make to this suggested lack in teacher training.

Should teacher training institutions include, as well as the areas mentioned previously, (using a productivity tool as a means for delivery of educational material etc.) some means of programming the computer to perform the educational tasks the teacher defines rather than restrict the computer's use to those educational tasks already defined by someone else?

Does this mean that the teaching of software production will change the focus from the use of the computer as an educational tool to one of programming techniques?

Is the amount of time required to program the computer too long for any teacher to seriously consider using it to create their own educational software?

Is available software and supporting hardware too limited at the moment to make the teaching of software production worthwhile?

Each of these questions should be considered.

Should teacher training institutions include Software Production as part of their training?

If it can be shown that, indeed, some tasks are best learned using the computer as opposed to other means, the answer must be 'yes' - perhaps with some qualifications. One of those qualifications may be: Only if the training of teachers in software production ensures that the educational software they produce is of sufficient quality to maintain those perceived advantages given by using the computer in the first place. The response to this qualification must be to ensure that the material taught includes information on guidelines for quality software production. By ensuring that known education principles are adapted to this new medium, teachers are as likely to produce quality educational material as they currently are, using any of the existing traditional media.

Will teaching Software Production change the focus away from education?

The concern is that a student teacher will have to learn vast amounts from an entirely different discipline if they are to become effective educational software producers as well as effective educators.

Is it not already the case that teachers intending to become Mathematics teachers must spend great amounts of time learning about Mathematics, Science teachers about Science, Humanities teachers about the Humanities and so on? It is not perceived that this causes any great harm to the student, rather that it broadens their knowledge and gives them greater depth on which to draw when teaching. Since the use of computers is seen as a cross curriculum issue should not every student teacher learn how to make best use of the computer within their own discipline?

This argument is supported by Duckett's (1992) modified version of Moursund's definition of Computer Literacy.

1. Knowledge and skill in operating a computer using a library of generic programs as determined by each discipline's requirements.
2. Knowledge of various ethical and social issues, in general, and in greater depth issues determined by each discipline, relating to computer use.
3. Knowledge and skills in computer programming using a high-level language as deemed appropriate or not by each discipline's requirements.
4. A functional level of knowledge for the use of computers as an aid to problem-solving, and roles of computers as a source of problems as deemed appropriate by each discipline students study in school.

In a subsequent article Duckett (1993) further refined Moursund's definition:

In global terms, to be Computer Literate a person would:

have comprehensive skills, knowledge and understanding of computers and their use as they relate to technical, ethical, social and educational issues of the day, as deemed appropriate to the skills, knowledge and understanding required.

As each discipline of study has specialised requirements, a global definition can extend no further than stated above. It is therefore the responsibility of each discipline to define:

the extent of skills, the level of knowledge and understanding of the use of computers, to be determined by each discipline, within its sphere of influence.

The next question: Is not the length of time required to create educational software too long for it to be of serious consideration to most practising teachers? Is the one which is most worthy of stopping the proposition dead in its tracks.

Up until a few years ago the answer would surely have been 'Yes'. However, with the introduction of software like HyperCard this is no longer the case. Certainly, attempting to produce educationally sound, user-friendly software for a microcomputer with a third generation language like Pascal, C or BASIC would have been prohibitively long and complicated for non-professional programmers.

However, using HyperTalk (HyperCard's programming/scripting language) and its accompanying tools, the amount of time required to produce effective, simple, educational software is not prohibitively long.

The factor determining the amount of time necessary is the complexity of the task to be performed. Therefore, a teacher attempting to develop software for a relatively simple task would require only fundamental programming/scripting knowledge. Only when the teacher's level of knowledge and expertise had increased would more complicated tasks be undertaken. When educators realise that using HyperCard to produce courseware does not necessitate the high, developmental costs in time normally associated with traditional development methods there may well be an explosion of activity in this area. Friedler and Shabo (1991, pp 136-137) report that when using HyperCard:

...trained teachers can approximate an 'hour for hour' development ratio, i.e. the development of one courseware-based teaching hour requires approximately one hour development time.

This one-for-one ratio of development time-to-teaching time is accepted by most educators as required for a well-prepared, traditional chalk-and-talk lesson. Even if the one-for-one ratio is an optimistic assessment of the time required to prepare computer-based courseware, it is a very good investment in time, since whatever is produced is an infinitely reproducible product capable of being shared between colleagues, re-used and modified without the repeat time investment of initial setting up.

Just to emphasise a point; the amount of time required to produce a corresponding software package by a well-trained programmer, using HyperCard as opposed to Pascal, would give a ratio of approximately one to six. HyperCard and similar packages are being used to prototype larger, more complex programs by software producers to give clients the feel of the product before it goes into production.

Of course, it is worthwhile remembering that not every learning task is best suited to the use of the computer or any single conventional teaching method. Many learning tasks are better suited to the type of interaction resulting from group learning or in one-to-one situations with a peer or a teacher. The use of a computer is not the ultimate method for learning in every situation. In those situations where the use of a computer is deemed ideal there are always alternatives. A teacher need not believe that they must produce computer courseware for every situation, only for those situations where they want to, where they have time and where they judge it appropriate.

Just as happens now with prepared units of work, teachers would be able to share what they have produced, significantly reducing the amount of work for other individuals. (Assuming that there is not an outbreak of teachers copyrighting their educational software!) As time passes teachers will build a library of educational software which they are truly capable of adapting and adjusting to meet changing circumstances, just as they presently do, with paper-based units of work. Entire libraries of educational software can be built up in schools paralleling the educational material which already accumulates in a more traditional form. Some of it will be of poorer quality than is ideal and some of it very high quality. Is this not true of the material currently prepared by educators? The possible advantages far outweigh any disadvantages.

In the Macintosh world the availability of HyperCard is significant in terms of the opportunities it opens for educators. It is certainly worthwhile using it as a platform for instruction of student teachers.

HyperCard has been chosen as the course presentation and developmental tool in a number of institutions because of its '...recognised short learning curve and potential for immediate benefits.' (Tucker et al 1990) Two other factors add to this point of view.

The first is that there are products available for the I.B.M. platform which perform similar tasks to Macintosh's HyperCard. Presently there is an I.B.M. package ToolBook and indeed there is an I.B.M. compatible version of HyperCard planned for the future. There is currently software that will translate Macintosh HyperCard stacks into Asymetrix's I.B.M. compatible ToolBook format. **

The second is the recent merging of Macintosh and I.B.M. to produce microcomputer technology which is capable of supporting software from both stables. While it would be foolish to predict that HyperCard will remain virtually unchanged and not be replaced by some other software which significantly improves on it, it would be just as foolish as the attitude held by some, that HyperCard can't be any good because it comes free when you buy a Macintosh. (This is sadly, no longer the case.) These are not sufficient reasons on their own to hold off making as much use of HyperCard as possible, NOW.

It is the familiar dilemma facing the potential purchaser of any high technology equipment such as a stereo. Does one buy now or does one wait just a little longer for the new 'bells and whistles' version rumoured for imminent release?

It is not sensible to hold off realising the benefits of existing technology indefinitely in the vague promise that greater benefits will be available sometime in the future. While one waits, one misses out on the benefits already available. Such a situation exists with currently available software in HyperCard and ultimately it is not only teachers that are missing out on the benefits, but their students also.

Teacher trainees could ideally have as part of their course a unit whose content would consist in the main of the skills and knowledge required to produce educational software. Such skills might include:

- the ability to determine the kind of learning task best suited to the use of a computer in preference to other means of learning.
- programmed learning techniques already used in other areas of education and their application to computers.
- guidelines for the design of effective user interfaces. (e.g. using a metaphor with which the user is already familiar)
- the ability to make valid measurement of the effectiveness of educational software.
- how to transfer an educational objective from a paper idea to a software learning package.

This list is by no means intended to be exhaustive, but merely an attempt to indicate the general areas which might be covered by such a course at tertiary teacher training institutions.

REFLECTIONS ON THE USE OF HYPERCARD AS AN AUTHORING TOOL BY A GROUP OF IN-SERVICE TEACHERS.

The participants came from disparate teaching backgrounds which ranged from infant teaching to technical and trade teaching. None of the participants were trained in the use of computers although all had some sort of contact with their use. In some cases this varied from the playing of computer-based games, word processing or using a computer operated lathe. In all cases the students felt some lack of confidence in the use of computers and felt that they ought to make better use of available technology for the benefit of their students.

Many worked in classrooms that had a computer where students worked to word process their written material and occasionally play games. Some had made use of commercially available educational software as part of a developed theme of work.

As is often the case with people new to computers it became apparent that most wished to learn more about the Macintosh computer, due to its availability in schools and its user-friendliness. As part of the assessment for the unit it was decided to include a requirement that each student create a software learning package.

The majority chose to use HyperCard. Others negotiated the use of an authoring tool for I.B.M. called "AuthorWare". The assessment requirements of the package was open-ended in that students had to choose a simple learning activity which, in their opinion, was suited to using the computer as a medium for learning. They then had to produce software that implemented the learning task. Assessment was not subject to the complexity of the task, in fact, it was suggested that the less complicated the task, in this instance, the better. Some background in software-development methodology was included as part of the lecture timetable and a one-day workshop 'Introduction to HyperCard' was sufficient to enthuse even the most sceptical student.

Within a very short space of time students were submitting first draft ideas for consideration and comment. Generally the initial suggestions were too complicated and had to be scaled down due to time considerations. Eventually each student decided on a viable topic to develop and refine during the remainder of the year.

Near the conclusion of the year another whole day was set aside for presentation of the assignments where the student audience was asked to complete criticism sheets for each piece of presented software. These criticisms were then used as the basis for a final refinement of the learning package before being submitted for lecturer assessment.

The final quality of the learning packages produced by those using HyperCard was very high. In every case the combination of educational expertise and basic software creation skills proved to be exciting and potent because of educational considerations such as:

1) readability of on-screen instructions
2) density of such instructions
3) flavour and consistency of the user interface and many other regular features of educational software, often poor in commercial software, were carefully taken into account and incorporated
4) exciting, because each and every piece of software produced was going to fulfil an educational need identified by that teacher in their working environment.

The attitude of those participating was exciting. The level of enthusiasm displayed by the participants was infectious. Small networks of students grew to fill the role of assisting other members of the class with a problem in which they were experiencing difficulty; a daunting task alone but solvable with the help of another member of the group.

It was difficult not to mentally extrapolate the possibility of this group dynamic into the work place where one could imagine a statewide network of HyperCard users; a network sharing home-grown software and assisting less-experienced users to surmount problems encountered. The diversity and breadth of such a potential pool of supply of educational software is very exciting. There exists an instructional software library called the "HyperMedia and Instructional Stackware Clearinghouse" where educators can submit created stacks for evaluation and acquire stacks already created (Tucker 1989, p. 32).

On many occasions participants in the course made enquires on behalf of their teaching colleagues as to whether or not this unit was to be offered in the following year. It appeared that other teachers had observed participants of the course, working on their learning packages or had witnessed participants demonstrating their work. They had been sufficiently impressed to make enquires.

CONCLUSION

To borrow the jargon from another discipline ...we are not responding to market forces. The market may be considered the body of educators in pre-service training, practising pre-tertiary educators and in many cases, tertiary educators themselves. This market is clearly stating that they are dissatisfied with the level of competency resulting from existing teacher training courses.

This paper proposes a response to this perceived market demand; namely, that the use of HyperCard or similar authoring tools be incorporated into PTE. This would fulfil the suggested, defined requirements for Computer Literacy appropriate to this particular discipline.

With any change to the status quo there are likely to be some problems encountered. Those best situated to ensure as smooth an implementation as possible are tertiary educators already working in the area of PTE. However, if for some reason, this lead is not taken it is possible that market forces may force the change in an ad hoc manner. The beginning signs are already there; it is happening. Anecdotal evidence abounds of HyperCard enthusiasts who use their own courseware in the classroom. The trouble is, that in all likelihood, they have received no formal (or informal) training in the production of quality educational software.

It is a market niche that will be filled. The question is not whether it will be filled but who will fill it?

** For more information write to, Heizer Software, 1941 Oak Park Blvd., Suite 30, PO Box 232019, Pleasant Hill, CA 94523, and ask for information about ConvertIt. and other HyperCard and ToolBook productivity software. Information about ToolBook is available in Australia from: Software Sanctuary, PO Box 542, Ashmore City, Qld. 4214 Phone (075) 972002.

APPENDIX A

FOCUS OF THE STUDY COMPUTER TECHNOLOGY AND EDUCATION:

Towards a Model Curriculum for Pre-service Teachers in Computer Literacy

OBJECTIVES

The study has four specific objectives:

1. Analyse major curriculum theories and models in terms of their applicability to the teaching of CIE.
2. Analyse current approaches to the teaching of CIE.
3. Based on the analysis of (1) and (2), identify the key elements, characteristics, etc. that must be present in a 'model' CIE curriculum.
4. Develop a model CIE curriculum on the basis of the criteria identified in (3).

ISSUES

To meet the objectives, the following issues must be addressed:

1. What are the leading curriculum theories/models which are pertinent to teaching pre-service teachers?
   (a) general
   (b) CIE
2. How do these theories/models compare with one another in terms of their applicability to the teaching of CIE for pre-service teachers?
3. What are the current trends/approaches to the teaching of CIE for pre-service teachers?
   (a) in Australia
   (b) abroad (US, Britain, etc.)
4. How do these trends/approaches compare with one another in terms of their effectiveness in teaching CIE for pre-service teachers?
5. Based on the above findings, what elements should be present in a 'model' CIE curriculum?

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THE PERSONAL COMPUTER AS A BUSINESS LAW TEACHING TOOL

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> ***The power of the personal computer enables teachers to be more productive in a variety of ways. For example, with word processing software computers can be used to write and edit research papers, to prepare exams and class materials and to draft correspondence. Spreadsheet programs can be used to calculate grades and maintain grade records. Communication programs allow access to E-mail systems and permit connection to mainframe computers.***

Using computer networks teachers can send messages worldwide and can conduct research by accessing information in libraries around the country from their desktops. Teachers use computers to be more productive at virtually everything they do as teachers—except for teaching itself.

Using personal computers and presentation software can improve classroom teaching and enhance the interaction between the teacher and student. Use of computers in education often focuses on computer assisted learning modules. These efforts tend to de-emphasize classroom interaction between the student and the teacher and replace it with separate events where the teacher interacts with the computer by programming the learning module and where the student interacts with the computer by working through the teacher designed program. Computer power is used to provide an alternative way of learning rather than improving classroom instruction.

This article describes an experiment using the Apple Macintosh®[1] and Aldus Persuasion®[2] presentation software to improve classroom teaching in Business Law. The project's goal was to apply the power of the personal computer to effectively organize and present information in the classroom just as it is used outside of class. The computer is used to increase teaching efficiency by making lecture material easier to produce, improve and present. Computer use can also improve student learning. Using presentation software to produce lecture visual aids with full color and graphics, the computer can improve instructional materials, increase attention and recall of course material, and improve student performance.

The personal computer has great potential as an effective classroom instructional tool. This article will first describe how this project was conducted. Second, it will describe the author's observations and reactions to use of this method. Lastly it will summarize results of surveys used to measure student reaction to the method.

PROJECT DESCRIPTION

In this project, nearly all lecture visual aids were prepared on an Apple Macintosh computer using Aldus Persuasion presentation software. The visual aids used color and graphics and were presented on large screen television monitors. In previous classes lectures were supported with basic visual aids — overhead transparencies and the blackboard. The overheads were black and white transparencies prepared on a personal computer. The blackboard was used for handwritten notes and hand-drawn diagrams. In this project the computer generated visual aids presented on the TV monitors were used to replace the overhead transparencies and the blackboard, which were used sparingly.

This method was used to teach three half-courses of Advanced Business Law, a course designed to teach legal topics tested on the CPA examination. Two half-courses were taught four hours per week for eight weeks. The other course was taught two hours per week for fourteen weeks. The material covered included commercial paper and secured transactions (Article 3 and Article 9 of the Uniform Commercial Code), and agency.

All 62 students were seniors. Over 90% were accounting majors. Nearly 25% were members of Delta Epsilon Sigma, the National Scholastic Honor Society on our campus. As a whole, the students were brighter and more highly motivated than students in the Business Law course required of all business majors.

Our university has only one classroom in which the Macintosh is connected directly to large screen TV monitors — a 228-seat science lecture hall. This setting was hardly ideal for classes with only 29, 18 and 15 students, respectively! Four 27-inch RGB television monitors are mounted throughout the room. The students tended to sit near the front of the room, but even the nearest students were 12 feet away from the TV monitor.

The computer hardware was a Apple Macintosh IIsi with a 40 megabyte hard drive and 5 megabytes of RAM. In addition to the classroom hardware, access to another computer on a regular basis is needed to prepare and edit the presentations. To make effective use of color capability, a color monitor for this second computer is almost a necessity. The second computer did not require as much power or RAM as is desirable for smooth operation in class.

The presentation software used was Aldus Persuasion, Version 2.0 and Version 2.1. Using Aldus Persuasion one can create classroom presentations from an outline format either by using pre-formatted slides or by creating new backgrounds and master slides. Persuasion includes several "AutoTemplates" which pre-format the master slide and background according to graphic design principles. Thus, preparation of a class presentation can be as simple as selecting the desired AutoTemplate and typing in the outline's content. For more customized applications, one can design new backgrounds using a myriad of colors, patterns, drawing tools and effects. New master slides can be made by specially designing the fonts and sizes for the text. In this project, nearly all of the master slides were adjusted to provide larger fonts and greater visibility. Copies of the Persuasion outline were distributed to the students to assist them in following the presentation.

The slides were presented on the TV monitors by running a "slide show" in which Persuasion advances from one slide to the next with a simple click of ter to make the desired presentation. This does not require that you know all facets of your computer's operating system or each feature of your software program. You need not be a "hacker" to teach effectively with the computer. But you must understand fully those particular functions essential to making your presentation run flawlessly in class.

You need to experiment with your software and learn its capabilities and limitations. The Aldus Persuasion program was extremely intuitive and easy to learn through trial and error and occasional reference to the program manuals. Other presentation software programs include MORE[3] and PowerPoint[4], which offer similar features and functionality. Regardless which presentation software you use, take time to learn its essential features thoroughly.

KNOW YOUR "OUTPUT DEVICE"

Computer generated visual aids can only assist learning if they can be easily and clearly viewed by the students. In this project the computer visuals were displayed on large screen TV monitors. The colors were clear, vivid and could be seen in a well-lighted classroom. If you use a large-image video projector, be sure your visuals will be projected brightly enough to be seen clearly. You may need to dim the lighting in the classroom to make them more visible. Using a color display panel that rests atop an overhead projector is somewhat risky. Often the colors can not be seen adequately unless the room is very dark. This will have a negative impact on visibility of the other aspects of the lecture. Only the brightest primary colors project vividly. If you need to use a display panel with an overhead, consider using black and white visuals instead. These will be more visible and will allow you to keep classroom lighting at a more acceptable level.

DON'T OVER-DESIGN

Adhering to this simple rule will help you avoid the mistake most commonly made by new users of technology: over-designing your presentation to demonstrate all of the bells and whistles of your wondrous computer and its incredible software[5]. This temptation is difficult to resist because you can impress your students as a computer whiz! During the first two half-courses, the author regrettably fell victim to this common beginner's mistake by designing 13 master slides and 10 backgrounds for use in eight commercial paper lectures!

Unfortunately this approach contributes nothing to your desired goals of greater efficiency, improved interaction and better learning. Designing new backgrounds was time consuming, especially at first. Merely selecting an AutoTemplate could have saved hours of work, so it certainly was not efficient. This time would have been more effectively spent improving the outline, or reviewing cases and problems for class. Second, it is doubtful that the new designs were any more effective than an AutoTemplate. Unless you are a graphic designer who understands the effective use of color and graphics to produce a good visual aid, your self-designed backgrounds will probably be less effective than the professionally designed slides. Third, overdoing fonts, colors, effects, etc., will distract the student from the content of the message — a result totally opposite from your goal. Thus, for the third half-course the presentations were converted to the standard Persuasion AutoTemplates.

MAKE IT EASILY READABLE

In this regard it is essential to modify Persuasion's master slides to suit your particular classroom's needs. Nearly all visual aids used in the project contained text only, which must be readable to be effective. A TV monitor's image is much smaller than that of an overhead projector. Before using your presentation in the classroom, check to be sure that all font sizes are large enough to be clearly seen. Readability may be a lesser concern if you project the computer output with a larger image using either an overhead projector using panel display or a with a video projector. However, merely projecting a larger image does not increase the effectiveness of the visual aid.[6]

A related issue is the amount of text on each slide. Selecting a large font that is easily visible will be self-limiting. However, even where additional room is available, do not overcrowd the slide with text. Limiting slides to no more than four bullet items of six words each underneath the main title is a good guideline. It is not always possible to conform technical UCC rules to this guideline, but limiting the content of each slide is worthwhile.

SLOW DOWN. MORE IS NOT ALWAYS BETTER.

The efficiency of presenting a new visual aid with a simple mouse click allows you to present material much faster than by using overheads or the blackboard. This method allowed you to present much more material in the same time. Unfortunately, the students are not always able to absorb and process the extra material.[7] Because the slides contain less content than overheads, they must be changed more frequently than overhead changes. If you don't pace yourself, the students feel like the slide disappears before its content can be read and understood.

Use the efficiency of this method to present better, not just more. Use the additional time to explain the material in more detail than previously possible, or to add another case example or problems to your lecture. Also take advantage of program features to repeat slides and reinforce your message before advancing to new material.

DISTRIBUTE HANDOUTS TO THE STUDENTS

Using the blackboard allows time for students to take notes as you write on the board. The blackboard information can stay visible while you write on other areas of the board. With the computer, however, new content is displayed instantaneously and disappears just as quickly when the new slide is presented. Students have less time to perceive and process the information. This can produce several negative effects. First, students become frenzied note-takers, not listeners or discussion participants. Second, students simply miss some of the information because they can't take notes fast enough. Likewise, they can't listen and respond and still take notes, or they suffer lapses of attention and when they recover, the slide content has already been lost to the new slide. This is especially true if you have difficulty teaching at a slower pace.

You can help the students to process the information more efficiently by distributing handouts. They can listen, pay attention and participate better when they are not in a note-taking frenzy. Slide content is not irretrievably lost when a new slide is displayed since it is in the handout for them to review later.

Using handouts creates other problems you should consider. For some students, note-taking is the primary reason for coming class. They may become bored if they feel they need not pay attention to the lecture because they "already have the notes". Admonish the students to take notes on examples, cases and discussion which add depth to the handouts' content. For other students note-taking may be a critical step in integrating and retaining information.[8] Remind these students to stick to their favorite study methods and use the handouts as a supplement when their own notes are incomplete, not as a substitute for their own notes. They still must do the mental work to assimilate and retain the information.

Avoid Reading the Projection Screens

This point probably seems obvious but interacting with the TV monitors can present unique problems. With traditional visual aids like overheads and the blackboard you'll see the content of the visual aid before the students. You have a moment as you write on the board or change transparencies to collect your thoughts and then segue into the topic. With the computer, you see the slide at the same time as your students and it can be more difficult to instantly match your comments to the visual aid. It is awkward, and even embarrassing, to introduce a topic and then find that your next slide discusses a different concept. The safest and easiest reaction is to read aloud from the monitor while you collect your thoughts on the subject—a colossal bore for students.

Avoiding monitor reading requires good class preparation and good lecture notes. Monitor reading is a much greater problem on days when class preparation is less than ideal. When first using this new method, you must review the slides, their content and order of presentation. You should know what will appear next on the slide even if you can't see it. Good lecture notes will prepare you for upcoming slides. Persuasion allows you to prepare lecture notes in a variety of formats. Finding the right lecture note format is a matter of personal preference and may require some experimentation. It is essential to be comfortable with the format you choose.

AVOID EXCESSIVE "LAYERING"

Users of overhead transparencies are undoubtedly familiar with the technique of revealing only a portion of the transparency to focus attention on the topic being discussed. As other topics are discussed, the paper is pulled lower across the transparency revealing additional topics. Persuasion allows use of the same technique through "layering". Selected portions of each slide can be assigned to different layers. Each consecutive layer is revealed by an additional click of the mouse.

The layering technique was frequently used in the first half-course, but use was reduced in the later half-courses for three reasons. First, extensive use of layering means that the slide is constantly changing. For the students, this means they constantly focus on the slide and comparing it to their handouts rather than listening. Conversely, if the entire slide is revealed, students can observe it, compare it to their handouts, make notes, etc., allowing more opportunity for listening and interaction. Second, extensive layering requires the instructor to constantly manipulate the mouse to advance to the next layer. This requires the instructor to remain near the mouse and limits freedom of movement in the classroom. Third, layering increases problems involved with monitor reading (see Rule 7 above) when the entire slide is revealed at once it's easier to formulate your thoughts about the entire slide. In the later half-courses use of layering was reserved only for the most important topics or where each layer was to be discussed in great detail.

AVOID EXCESSIVE TRANSITION EFFECTS

Persuasion provides 13 special effects to make the transition from one slide to the next. The transition effects can apply individually to each slide, or the same effect can be applied globally to all slides, or various effects can be applied at random. These are the bells and whistles that are so tempting to show off to the class!! Initially a variety of transition effects were used in the class presentations and some were assigned randomly. While this initially generated student attention it ultimately distracted from the students' attention to the teaching message.[9] As the courses progressed a single transition effect was applied for each major portion of the lecture. Effects were changed only when beginning discussion of the next major topic.

IMPORT TEXT FROM OTHER PROGRAMS

If you already use overhead transparencies, you may have developed them using a word processing program. Persuasion allows you to import the text into Persuasion. The imported text needs to be reformatted into slide format, but you will not have to manually enter the text. Although some time was required to convert the imported text to slide format, it was not especially difficult and resulted in a substantial time savings over manually entering the text.

TEACHING TASKS SUITABLE FOR COMPUTER GENERATED VISUAL AIDS

Using computer generated visual aids effectively in class requires advance preparation of the visual aids. Unlike the blackboard, computer visuals cannot be prepared spontaneously. And unlike previously prepared overheads, the computer visual aids cannot be edited in class by writing additional information on the transparency with a marker. The tasks for which computer generated visual aids are most effective are those which can be prepared in advance and are unlikely to change. The tasks for which computer generated visual aids are least effective are those which require greater spontaneity and easy revision.

In the Business Law context, computer visuals are best suited for teaching "black letter" law such as defining legal terms, listing UCC legal requirements, explaining elements of rules of law. For example, for listing the elements of a negotiable instrument under UCC Article 3 and explaining the meaning of each requirement. This method also worked well to describe legal relationships between parties such as the relationship between principals and agents in agency law. The method also can effectively be used to explain a step by step approach to analyzing problems involving commercial paper and secured transactions, then reinforcing the approach for each case and problem discussed. Although not editable in class, the computer visuals can be more effective visual aids because they are carefully formatted, edited, and refined before class.

While most computer visuals in this project were only text, they also were used to graphically represent relationships between parties during discussion of the cases and problems in class. These visuals enjoyed limited success. The students were asked to describe the case or read the problem and then initiate discussion of the legal issues. Such a discussion approach is more spontaneous and not well suited to a previously prepared computer visual aids.

The blackboard is the most useful visual aid for discussing cases and problems because it allows more spontaneity. A blackboard diagram of the parties' relationships can be prepared as the student discusses the problem or describes the case. In addition, its easy to discuss variations of the legal issues by modifying the facts of the problem and modifying the blackboard diagram as well. Such impromptu revision is not possible with the computer generated graphics. Unfortunately, the quality of blackboard visuals often are not very good. Some diagrams are not fully legible or comprehensible and require on the spot editing. Overhead transparencies combine the good qualities of prepared visuals with the spontaneity of the blackboard. The basic elements of the problem can be carefully prepared in advance, while spontaneous revisions can made by writing additional information on the transparency with a marker. Both the blackboard and overhead transparencies work better than computer visual aids for case and problem discussion.

The computer was helpful, however, for instantly retrieving the legal definitions, elements of causes of action or legal principles that related to the cases or problems under discussion. For example, as a student discussed a problem regarding a party's status as a holder in due course, one could immediately display the screen describing the elements required to be a holder in due course. If the issue focused on a specific issue (such as whether value had been paid by the holder of the instrument) one could instantly display the screen related to value issues. In preparing for class, you should review the cases and problems and make notes regarding which screens applied to the issues made in the case or problem. When the students discussed the legal issues, you may immediately present the slide containing the applicable rule of law.

Another limiting factor for effectiveness of computer generated visual aids is the inability to display a large amount of information at once. This method requires you to divide the material into small components visible on a single TV screen. Occasionally large amounts of related topics must be presented at once and cannot be effectively presented in screen-sized portions. For this material, overhead transparencies are superior. Because overheads project such a large image, even transparencies with large amounts of material will be readable.

INSTRUCTOR'S OBSERVATIONS ON THE EFFICIENCY AND EFFECTIVENESS OF TEACHING WITH THE PERSONAL COMPUTER

The personal computer has great potential as a teaching tool. But its high-tech nature and use of color alone will not ensure that it is demonstrably superior to other presentations methods. Computer assisted teaching methods are not automatically better. This method, like any other, must be used properly to be effective. Similarly no single method is appropriate for every teaching task. Computer generated visual aids should be used only when their unique capabilities can assist, rather than impede, teaching. If this method is used appropriately, you can capitalize the personal computer's potential to help you become a more efficient and effective teacher.

EFFICIENCY

Using this method requires an initial investment of time and effort that will pay off in future courses. There is a definite "learning curve" in mastering the hardware and software, preparing the slides and adjusting to in-class use of the presentations. Once this initial loss of efficiency is overcome, this method can save time in several ways.

In class, there is no question that time is saved in handling the visuals aids when compared to using the blackboard or overheads. A simple mouse click advances to the next slide. Any slide can be accessed in seconds with a keyboard command. The time saved can be used for other teaching tasks. But remember to teach better, not just more. Using the computer kept the materials more organized and the computer visuals were convenient to use. Previously six manila folders of overhead transparencies were used for the class. Now all of the visuals for the class fit on just two floppy disks. The individual slides never get misplaced, fall on the floor or get out of their designated order.

Outside class, editing the presentations is easier than reproducing new overhead transparencies. Editing the content is no more difficult than editing in any word processing program. The order of the slides can be rearranged in seconds. With overheads, the changes must be printed and copied to transparencies. Even small changes sometimes can require several transparencies to be reproduced.

Admittedly, the time difference between editing slides and reproducing overheads is not always dramatic, but it can impede slight adjustments to fine tune a presentation. Users of this technology will be more willing to adjust their presentations for a particular class than to change overhead transparencies. In the author's experience, overheads with slight defects have continued to be used for several semesters rather than take the trouble to reproduce the transparency. With the computer visuals, slides were frequently added or reorganized and information was edited to improve the presentation. Often changes were made either just before or just after class.

The major threat to using this method efficiently lies in the temptation to overdesign the computer visuals and demonstrate special effects. While it can be enjoyable to "play" with the computer's capabilities, these efforts can take substantial time and yield only a marginal impact on learning in class. The time would be better spent by thoroughly preparing other materials to lend variety to the class, such as cases and problems for discussion.

EFFECTIVENESS

Quantitatively and objectively determining the educational effectiveness of this method would require great effort to control the many other educational variables operating in a Business Law classroom that were beyond the scope of this project. Important qualitative evaluations can be made, however, based on the author's personal observations and on the course evaluations.

This project began with two basic assumptions. First, that increased educational stimulus would increase learning, and second, that the color capability of the computer would have a dramatic effect on learning. Both were only partly true. Merely adding stimulus does not increase the effectiveness of the message because not all stimuli serve as cues which facilitate learning.[10] Color can advance student learning if used carefully to support specific educational objectives.[11] Thus, while the additional stimuli and color of the computer generated visuals can advance learning, it cannot be presumed they will.

Used properly computer generated visuals aids are an effective means to increase learning. Persuasion permits the use of color in ways that can serve as effective cues for specific learning objectives. Due to the many variables that affect learning measuring the relative effectiveness of color is difficult. Studies of color's relative effectiveness for learning are inconclusive, and even contradictory. While early studies of the use of color tended to show no improvement in learning through use of color more recent studies show use of color to be a viable instructional variable.[12] A summary of fourteen studies during the period from 1975 - 1990 concluded that color facilitates both recognition and recall tasks. Color also was found to be superior to black and white images in encoding information into memory.[13] The author's personal judgment is that this teaching method generated a classroom atmosphere in which students were better able to more effectively understand and retain the complicated concepts presented in commercial paper, secured transactions and agency.

In addition to the potential for more effective learning, using color visuals can improve the student interest in the class. Color is known to be an effective method for gaining and sustaining attention.[14] This can be critical when teaching a technical subject such as commercial paper. This method generated great initial student interest in the visual aids. Student interest naturally waned slightly as the students become more familiar with the method. Varying presentation methods during each class period will sustain the student attention generated by the visuals. Variety prevents students from being mesmerized by the screen and losing attention. Use of overheads, the blackboard and discussion of cases and problems should be liberally interspersed with the computer visuals.

Arbitrary use of color and special effects is an impediment to effective use of this method. Care must be taken to focus the use of color on specific learning objectives. One study suggests that color improves memory of only peripheral information and not the central material.[15] These studies provide even greater reason to avoid distracting overdesign of Persuasion slides and minimal use of peripheral effects such as transition effects and layering.

A second problem hindering effectiveness is that over reliance on the computer visuals can negate any advantage of increased attention. In the second half-course, the computer visual aids were used more extensively and fewer spontaneous discussions of cases and problems were held. As a result, half of the students felt the method reduced their attention in class. Over reliance on the computer visuals interferes with classroom interaction between the students and the instructor. The method becomes impersonal and limits the instructor's effectiveness.

Excessive speed is a third factor limiting effectiveness of computer visuals. In this project students receive an auditory stimulus (the lecture) and two different visual stimuli (the screens and the handouts). The capacity of the human senses to transmit information to the brain far exceeds the ability to process information effectively.[16] It is largely unknown whether multiple stimuli enhance or impede learning and recall.[17] Lecturing too quickly most certainly compounds the problems related to processing the multiple stimuli students receive from this teaching method. Failure to give students enough time to view and study the slides may negate any effectiveness of the color presentation and may even reduce learning.[18]

Distributing copies of the visual aids is important to the effectiveness of this method. The efficiency of the method will be lost if you must wait as students take notes from the screens. If you tend to cover material quickly in class it will be critical to distribute handouts or students will have trouble keeping up with notes. This is especially true if the visuals include a lot of content and detail, rather than mere bullet points of general topic headings. For less detailed presentations, handouts are not as essential.

A complete set of handouts gives students the comfort of knowing they won't "miss anything important" in their notes if they concentrate on listening and participating rather than note-taking. The handouts also help the students to connect related topics that have been separated into two or more slides.

Using computer generated visual aids in the class appears to have a strong positive effect on student evaluations of the instructor. Appendix 1 contains a summary of the author's mean scores on the University of St. Thomas' standard student evaluation of teaching. The results of the three experimental half-courses (the "1992 courses") were compared to those of three previous half-courses taught in 1991 (the "1991 courses"). The overall rating of the instructor (Item 18) in the 1992 courses greatly improved when compared to the average of the 1991 courses. The overall rating increased each semester as the author became more familiar with the method. Moreover, higher evaluation scores were received on nearly all questions regarding in-class performance. The most significant increases appeared in evaluation of instructor preparedness, good use of examples and illustrations, clear course objectives, instructor's knowledge of the subject matter and clear presentation of the subject matter. Again, in each of these areas the evaluation scores have increased each semester as skill in using the method increased.

In the first 1992 course, the overall evaluation of the course was lower than the 1991 course average. Lower evaluation scores were reported in key areas such as how much the students learned, their ability to use course concepts, and ability to read the subject matter better. In the second and third 1992 courses, as adjustments were made and use of the method became more familiar, these results were reversed for nearly all categories.

While the improved course evaluations were gratifying, they should not be interpreted as proof of a better learning outcome. Research indicates that learners prefer to receive and interact with presentations in color rather than black and white.[19] Material presented in color is rated as being better, more interesting and more active than that presented in black and white.[20] In a study involving overhead transparencies, color contributed positively to audience perceptions of the presenter of the material and the presenter was found to be more persuasive.[21] But only a small relationship exists between learners' preferred types of visual presentations and achievement of specific educational objectives.[22] In other words, while students may prefer color, and they may rate instructors more highly on course evaluations, they are not necessarily learning more effectively.

One final observation. Student surveys from the 1992 courses showed that some students clearly disliked the new method. However, no two students learn in the same manner and students will perceive and react to a common stimulus in different ways.[23] Individual differences in students, such as intelligence and prior knowledge, also will affect the students' reaction to visual presentations.[24] Until individual learning styles can be identified and accommodated, striving to meet the needs of most learners while providing variety which addresses other learning styles is the best solution.

RESULTS OF STUDENT SURVEYS

Accurately measuring the effectiveness of computer generated visual aids for teaching Business Law as a result of this project would be extremely difficult. First, no control group was used for this project so direct comparisons are impossible. Second, there are an infinite number of variables associated with effective use of visual aids in teaching[25] and no attempt was made to isolate these variables. Third, attempts to compare the 1992 courses with the 1991 courses are hampered by numerous variables other than the type of visual aids employed (course length, subject matter, room size, etc.). Thus while no quantitative results can be reported from the project, the responses to the student surveys provide important qualitative measurements to evaluate the effectiveness of this teaching method.

Before the final exam the students completed a survey about the use of the Macintosh and Persuasion as a teaching tool. The surveys were distributed at the same time as the university's course evaluation forms. The survey questioned the students' perceptions of the method's effect upon various aspects of their learning and upon instructor performance. Students also were asked to compare the method to those used in other courses taught by the author and by others, to assess its effectiveness for various tasks and to rate the manner in which the method was used. The survey questionnaire was used. (Please see note at the end of the footnotes Ed.) Results from the third 1992 course have not yet been compiled. This section will discuss the results of the first two 1992 courses.

Studies of the effect of color visual aids have been contradictory and this survey was no exception. In general, students in the second half-course rated the method less favorably in most categories than students in the first half-course. This was unforeseen since one would expect the method's effectiveness to improve as the user became more accustomed to it. Moreover, it was surprising since the second-half students gave much higher ratings on the standard course evaluations they had completed at the same time!

Student responses to thirteen open ended questions were summarized into groups of generally positive comments, generally negative comments and comments of either "no effect" and "other". Next, within each group the responses were further sorted based on the factors students identified that influenced their positive or negative response.

The strongest positive effect was shown in student perception of instructor preparedness with 80% positive responses and only 8.8% negative responses. Perception of instructor knowledge (55% positive and 17.5% negative) and instructor overall effectiveness (51.3% positive and 23% negative) also were favorable. Most students felt there was no change in instructor effectiveness as the course progressed (55% no change). However, of those who perceived a change in effectiveness, more students in the first half-course felt the effectiveness improved, while more students in the second half-course felt the method became less effective.

Student perceptions of how this teaching method affected the course were generally positive. The strongest positive perceptions were shown in the student perceptions of how much they learned (61.9% positive, 9.5% negative) and in ability to retain and recall course material and concepts (59.5% positive, 7.1% negative). Most students felt the method made learning the material less difficult as well (53% positive, 26.5% negative).

The effect of the method on student attention, while rated positively overall, provoked the greatest negative response. The students were sharply divided regarding whether the method improves or impedes attention in class. 46% felt the method increased attention although 37% said it negatively affected attention. The primary reason cited for the reduced attention was an inclination to rely solely on the handouts for the information and tune out the instructor. The drop in attention was particularly acute in the second half-course, in which half of the students reported a negative effect on attention.

The impact on students' interest in the class received the next largest negative response, 26.2%. 42.8% gave positive responses. Oddly, very few second half-course students reported losing interest in the class, although they had a hard time remaining attentive. For this question the first half-course students gave nearly as many negative responses as positive responses. The reasons were varied, but a lack of participation and general boredom topped the list.

The computer generated visuals failed to generate additional participation in class. 68.3 % felt the method did not affect their participation, but the 22% who said the method decreased participation were more than double the 9.8% reporting increased participation. In the second half-course only one student responded positively, while six said participation was hampered.

The factors causing the positive and negative comments also are instructive. Overwhelmingly, the most frequently mentioned positive factor was the Persuasion outline handouts given to the students. Handouts were a key factor cited in how much the students learned, retaining and recalling the course material, and making the material less difficult. Use of the color visual aids was the next most frequently mentioned factor, followed by "organized", "permits better listening" and "easy to follow". Negative responses most frequently mentioned were an over reliance on the handouts which hurt attention in class. An equal number of responses found the presentations boring. Other noteworthy negative responses concerned difficulty seeing the monitors, the speed of instruction, amount of material and lack of examples.

The students most frequently cited the handouts as the greatest strength of the method. Students also said the method was organized, allowed for better listening, was easy to follow and allowed them to concentrate better. No single aspect of the method was stood out as its greatest weakness. The most frequently mentioned weaknesses were that the method was more impersonal, boring, and ill-suited for doing diagrams.

Students viewed this teaching method favorably when comparing it to other methods. Students in the first half-course found the method more effective than lecture alone, lecture and blackboard, lecture and overheads and lecture with overheads and handouts. The use of visual aids appears to affect student opinion of effectiveness since the method was rated much better than lecture alone. The differences decreased as visuals were added to the lecture format by using the blackboard and overheads.

The computer generated visuals were rated slightly more effective than the lecture format with overheads and handouts. This was true both for those who also had taken Business Law with the author and for new students. Similar results were found in the second half-course with one notable exception. Students who had taken Business Law with the author found the method to be slightly less effective than using overheads with handouts. This result is attributed to the lesser degree of interaction with the class in dealing with cases and problems than in the first half-course.

The students rated the method most effective for the task of defining legal terms (nearer to "very good" than "good"). The method was slightly less effective for the tasks of explaining rules of law, describing legal relationships and explain rules of legal liability (midway between "very good" and "good"). The effectiveness rating was roughly equal for all three tasks. The method was rated least effective for discussing cases and problem (midway between "fair" and "good").

The students were surveyed regarding the manner in which this teaching method was used. Their most significant concerns were the amount of material covered, the speed in lecturing about the screens and the speed in changing screens. Efforts to slow down in the second half-course reduced criticism regarding speed, but the students still felt too much material was covered. A second concern was the amount of layering. Even though much of the layering was eliminated during the second half-course, students still found it problematic. The amount of content on each screen and the use of color were well received. The students rated the handouts very highly.

To summarize, the student surveys indicated use of the computer generated visuals will have a positive effect on how the students view the instructor's performance. They believe the method helps them learn and retain the course material while making it seem less difficult. Attention to lectures and interest in the class were adversely affected for a substantial minority of students. This may be addressed by varying classroom presentations to include more participation in the form of cases, problems and discussions. Students love handouts, but handouts cause some students to lose interest in class because they have the lecture material already. The method was preferred when compared to other lecture formats both with and without use of other visual aids. Students found the method unsuitable for facilitating discussion of cases and problems in class. The problems identified in the manner of use of the method were excessive speed both in lecturing and changing slides and overuse of layering. And, of course, the students as usual would rather cover less material.

CONCLUSION

Using personal computers and presentation software gives teachers new ways to enhance their classroom performance. This project demonstrated that using the Macintosh and Aldus Persuasion presentation software to produce color visual aids is an effective teaching tool. From this project, better ways to use this method effectively were discovered and the tasks for which computer generated visual aids are best suited were identified. With further refinement, use of this method can create an efficient and dynamic classroom in which the use of color helps students and learn and retain more information. As these experiments continue, the personal computer will prove to be a useful tool for teacher who wish to be both more efficient and more effective in the classroom.

FOOTNOTES

[1] Apple and Macintosh are registered trademarks of Apple Computer Inc.

[2] Aldus, Persuasion, and AutoTemplate are registered trademarks of Aldus Corporation.

[3] MORE is a trademark of Symantec Corporation.

[4] PowerPoint is a registered trademark of Microsoft Corporation.

[5] Antonoff, "Presentations that Persuade", Personal Computing, pp. 60-68 (July 1990).

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[25] Dwyer, F. M., Strategies or Improving Visual Learning, p. 15, State College: Learning Services (1978).

Editor's Note

A copy of the survey questionnaire is available from the author who may be contacted at the School of Business Law, Curtin University of Technology, Perth, Western Australia or the University of St. Thomas , St. Paul, Minnesota,

TEACHER CHANGE: PHILOSOPHY AND TECHNOLOGY

BY HELEN MCDONALD,
a secondary English teacher and currently a Ph.D. student from Monash University, has been conducting research at Methodist Ladies' College, Melbourne in the field of educational change.

Computers and their related technology may be relatively new to the educational scene, but the process of change is not. Persuading people to change is rarely an easy task. Change can seem threatening, it can bring insecurity, anxiety and a great deal of hard work. The process of change is personal and time-consuming, requiring commitment and support. Thus to embark on what may be a difficult process (and perhaps a stimulating and exciting one) requires a conviction that the journey will be worth it - a belief that the outcomes are worth achieving.

This paper looks at the relevance of a firm philosophical foundation as a basis for technological change. It also notes the importance of action-research in reassessing the purposes, beliefs and practices of teachers. Much of the research referred to relates to a case study of Methodist Ladies' College, Melbourne, where a program based on independent learning and utilizing laptop computers has been operating since 1990.

Change can be achieved on many levels, from a superficial adoption of a few visible facets, to a complete assimilation of the change which challenges and alters old structures and existing beliefs. Real change must go below the surface, beneath the adoption of hardware and software, beyond the acquisition of new skills. For teachers it means looking at learning and re-examining its processes.

> *I need three more days in the cycle to be able to get through all of this! I feel like I can never do anything properly: I'm just skimming over the surface. I haven't got time to read what I need to read and I haven't got time to digest it. Look at this pile of work I have to get through!*
> *Please - no more change! We haven't got through the last one yet. I need to have time to think about what I am doing instead of changing it every five minutes!*
> (M.L.C. teacher Feb. '93)

To many teachers, frequent change is not an attractive proposition. It is too demanding, too exhausting and often doesn't seem worth the effort. Change takes time and it often requires the relinquishing of control. No wonder that some teachers prefer to "cultivate their gardens", changing things they can control - small pieces of the syllabus; additions to a program - safe innovations that are manageable. (Huberman, 1992, p.5) By so doing they avoid the roller-coaster ride of major change which may exhilarate one minute, and plunge innovators to the depths of despair the next.

At Methodist Ladies' College in Melbourne, the roller coaster ride is mandatory for all staff. The climate at this school is demanding but it also encourages risk-taking, supports innovators, invites experimentation, copes with mistakes/problems and celebrates achievement. Envisioned as "a learning place for teachers as well as students" (Loader, 1993, p.6), M.L.C. seems to have developed an institutional capacity to innovate. Coping with change appears to improve with practice and many of the existing staff are well-versed in the process. The administration both supports and encourages (or some may say pressures) active participation in innovative programs and has established formal networks to facilitate change. That is not to say that all change at M.L.C. is successful, nor does it come without the associated "pain and disorder" which are "healthy signs" of school improvement. (Huberman, 1992, p.6)

The particular change upon which this paper focuses is one of many occurring at M.L.C. and should be seen in that context. The innovation centres upon constructionist thinking and the encouraging of effective independent learning at Junior Secondary level (Years 7 and 8), although both concepts are not exclusive to this section of the school. Linked significantly to this philosophical base is the integration of laptop computers and the use of LogoWriter.

The Principal, David Loader, speaks enthusiastically of M.L.C's move towards a more constructionist approach, which centres upon the individual student's learning:

> *This approach is based upon Piaget's "constructivism" where knowledge is "built by the learner, not supplied by the teacher." This idea has further been extended by Seymour Papert to "constructionism" which includes "the further idea that this happens especially felicitously when the learner is engaged in the construction of something external or at least shareable ... a sand castle, a machine, a computer program, a book."* (Polin, 1990. p.6)

> *The idea of knowledge being constructed by the student shows appropriate respect for the intellect of the learner and reflects the subjective and evolutionary view taken of knowledge. The student, in such a view, is not a passive recipient of data but a constructionist trying to understand her world, having meaningful experiences, making personally significant connections, developing mental models, collaborating with others in an enriched teacher supported social setting.* (Loader, D. 1993, p.4)

In M.L.C.'s Junior Secondary School, this view became woven into the philosophy of independent learning. The aim was to create a learning environment which highlighted individual differences rather than suppressing them. Students were encouraged to work effectively without constant direct instruction. They could set their own working pace, have some flexibility in areas of study, and pursue options which motivated them - all within a framework provided by the teacher. "Learning experiences" were emphasized rather than "teaching programs" as students were encouraged to take responsibility for their own learning. Their role became more active: observing, participating, working together, constructing and reflecting . In fact, "independent" learning is perhaps, a misnomer as the relationship with teacher and peers is more "inter-dependent" and co-operative.

Computers and other forms of technology, were seen as having strong potential in assisting the implementation of these beliefs and so were introduced concurrently. In 1989 a pilot class was taught by a team of three, following the ethos of independent learning. Four computers were located in the classroom as a resource and the program LogoWriter, was used.

In 1990, four Year 7 classes took the innovation on board, with one class using laptop computers. School policy requested that each student in this class own their own laptop computer at an initial cost of approximately $1,500. The success of the project and subsequent parent demand saw nine out of 10 classes in 1991 and 1992 using laptops, while the remaining classes had daily access to the computer network. In 1993, all year 7 students use their own laptop computer. LogoWriter has been integrated into English and the Humanities (History, Biblical Studies and Geography), Mathematics, Science. and some L.O.T.E.. In teacher terms, the team expanded each year, attracting like-minded staff until the change became policy and all Junior Secondary teachers became involved.

Many people both within and outside the M.L.C. community tended to view the highly visible laptops as "the change". Some labelled it as a "gimmick" or an "enrolment booster" - part of a technological bandwagon that would provide a clear advantage to those who were a part of it. However, those who initiated the program would argue that the laptops were introduced only to facilitate and enhance the possibilities created by independent learning. In many ways, laptops were not the change: the change was in thinking, in learning and in teaching. The technology supported the change as a rich resource.

As one M.L.C. teacher stated:

> *You can't put a kid in a classroom with a laptop and LogoWriter and expect miracles to happen. The computer itself doesn't do a thing for you. It needs someone to make it happen, someone to give you ideas. It needs a philosophy of how and why we are doing it - it needs an aim. It needs people who know how to go about achieving it.*
>
> (Interview: 2/4/92)

And so the teachers who worked in the Junior Secondary School had to assimilate the views of constructionism and independent learning with their own personal educational outlook. For a few - particularly the initiators who were involved in the pilot program - the philosophy, the technology and their own educational outlooks were compatible from the outset. For others, the task was not so easy.

Some accepted the philosophy, but shied away from the laptops and the technology entailed. Others embraced the computers, seeing the technology in terms of professional development and as a means of enhancing their teaching. A third group wished only to continue "cultivating their gardens", and tended to accept the trappings of the change without significantly altering practice.

However, there does seem to be a point where these paths can merge. Once teachers have come to grips with the more operational aspects of the change (whether it be computers or independent learning) , they begin to build the mental models necessary to provide inroads into the other aspect of the change. For example, the teacher who embraces computers soon comes to realize that students can and do work more independently with the laptop. The flexibility provided in recording, generating and presenting information allows students more scope. The medium also seems to encourage more frequent interaction among peers - such as group problem solving. Whether intentionally or not, the teacher's role in the classroom changes. No longer the expert, the teacher must learn to facilitate. No longer the instructor, the teacher guides. The philosophy of independent learning becomes relevant and the reality of the classroom makes the connection between beliefs and practice.

Alternatively, for those who believed in the philosophy, the value of laptops and LogoWriter quickly becomes apparent. As students use LogoWriter in most subjects, they begin to utilize its functions across subject boundaries. Teachers do not need a great deal of technical expertise to allow the laptop to be used as a tool in their classes. They do not need to be master programmers to mark a piece of work on disk. As they see the technology assisting students with organization, drafting and problem solving, it quickly becomes apparent that its link with independent learning is a valid one.

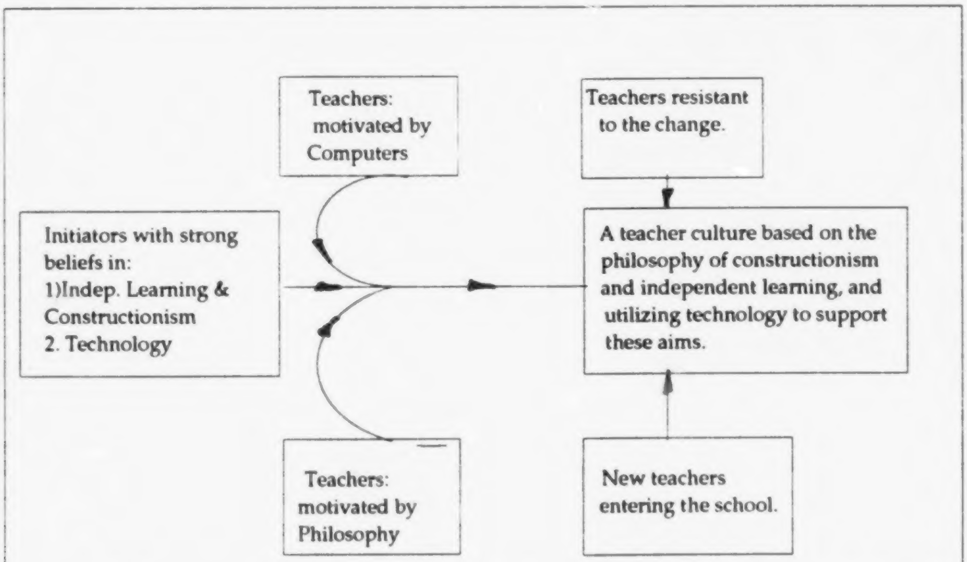
The third group, teachers who are resistant to the change, can be quite successful in limiting changes to practice but only for a short time. As students become skilled with the technology, they begin to use it in all subjects. A teacher who does not encourage computer-use soon becomes visible and has to deal with a situation where students expect consistency of approach both in classroom operation and learning style. Students do not react well to a student-centred approach in five classes and the traditional teacher-centred approach in one.

This reticent teacher group, although not experiencing the changes first hand, can not fail to observe the educational outcomes as they become apparent. Subject meetings soon include frequent demonstrations of successful programs generated by colleagues; the staffroom conversations introduce the jargon associated with both constructionism and computers and the administration begins to insist that all reports are generated using a computer. As the culture of the school alters, those who avoided the change feel increasingly "left behind".

To meet the needs of all teachers, a support system must continue to provide opportunities for staff to tap into a learning network which allows participants to obtain new knowledge and skills as the need arises. Gary Stager (Interview: 1991) described it as "casting small nets" - to encourage teachers, at the point where they feel ready, to "have a go" and to be part of the emerging culture. New staff entering the school must also be catered for, as they bring with them knowledge and skills which may further build the culture, but may also need support to acquire the skills necessary to teach in the established program.

Hence, although the school succeeded in providing a solid and appropriate philosophical foundation for the introduction of technology, teachers often had to work with laptops and within the new structures - forging their own links and meanings. As Fullan (1992: p. 25) states " It seems that most people do

This process where the divergent paths tend to converge may be illustrated diagramatically:
Figure 1:


Teachers: motivated by Computers
Teachers resistant to the change.
Initiators with strong beliefs in:
1)Indep. Learning & Constructionism
2. Technology
A teacher culture based on the philosophy of constructionism and independent learning, and utilizing technology to support these aims.
Teachers: motivated by Philosophy
New teachers entering the school.

not discover new understandings until they have delved into something. In many cases, changes in behaviour precede rather than follow changes in beliefs." Some teachers also need to see outcomes emerging before committing themselves personally.

The importance of "beliefs" and "understandings" is central to the success of a change process. As Michael Fullan states:

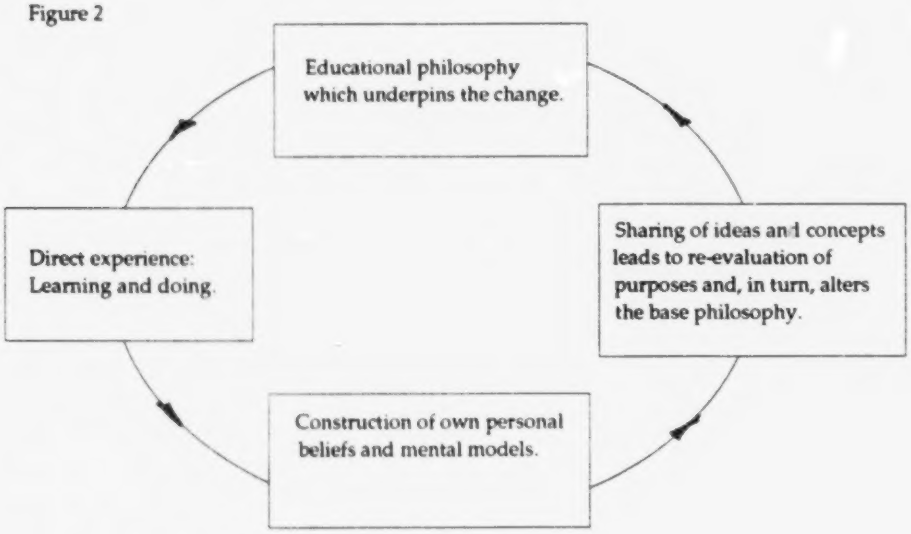
> All substantial innovations have underlying beliefs, rationales or philosophies...(Those involved will) have to come to understand and believe in the new assumptions and ideas that underline that reform.
>
> Fullan, M.G 1991, p.2

However, the point in the change process where that meaning is obtained is not set or fixed. If a school's philosophy is based on constructivism, then teachers too must be encouraged to build their own mental models and develop their own meanings and beliefs. This includes the active provision of experiences which confront theory and allow for the evaluation and re-evaluation of aims and purposes. As teachers conduct and share their own action-research, meanings can be exchanged and a culture extended which includes and accepts the experiences and beliefs of all participants.

In such a learning environment one needs to see learning philosophy as fluid and as changing. Just as teachers are influenced by the provision of a set of beliefs and concepts, proposed as a foundation for teaching and learning, so does their experience influence and alter the educational philosophy. Action-research may result in the extension of ideas, changes in emphases, the rejection of some concepts and the integration of others. And so the cycle of theory and practice continues, constantly evolving.

Fullan and Miles (1991) describe "change" as "a process of coming to grips with new personal meaning ... a learning process." It requires the participants to alter their purposes, develop commitment to new ways and to "unlearn old beliefs and behaviours." (Fullan and Miles, 1991. pp10-12) As such it requires great effort from individuals who must cope with anxiety, difficulties and uncertainty as they seek , not only to introduce an innovation but to change the culture of their schools.

Figure 2


Educational philosophy which underpins the change.
Sharing of ideas and concepts leads to re-evaluation of purposes and, in turn, alters the base philosophy.
Construction of own personal beliefs and mental models.
Direct experience: Learning and doing.

To embark on major change - to take on board new ideas and skills is demanding. Change takes effort and a great deal of commitment. Anxiety, uncertainty, frustration, overload, lack of skill, complexities, incompatibility: all were experienced in the M L.C. study.

The process of change is not easy as the comments below indicate:

> *It was the most frustrating thing I've ever been through. There was a lot of expectation placed on teachers ... the approach was made compulsory, but where do you find the time to build new skills? It was assumed we would do it, assumed that you would understand and be able to cope - but some people did not understand and some didn't cope and some didn't really try.*
> (Interview 6/12/91)

> *It's exciting, but you wonder how long people can maintain this enthusiasm and commitment... you wonder how long teachers can keep up the pace and the pressure. The environment for the kids is fantastic - they have exciting experiences, computer experiences and all that. But the teacher workload is very, very high.*
> (Interview 19/3/92)

If the process of change is to be experienced as accomplishment rather than frustration, a strong sense of purpose needs to be accompanied by many practical considerations.

As Linda Darling-Hammond writes:

> ...the process of change is slow and difficult. It requires perseverance, and it requires investments in those things that allow teachers, as change-agents, to grapple with the transformations of ideas and behaviour: time for learning about, looking at, discussing, struggling with, trying out, constructing, and reconstructing new ways of thinking and teaching.
>
> L. Darling-Hammond 1990 p.240

In practical terms M.L.C. did much to support staff with workshops, rebates for computer purchase, educational courses, classroom support, access to information and a network of people who could provide assistance.

Most activities were voluntary and repeated, thus allowing staff to join in when the experience would be most meaningful and/or convenient. One of the most worthwhile professional development options was the running of residential workshops, which took staff away from their usual commitments and provided the time "to play" with LogoWriter and discuss philosophies of learning in a supportive environment. As well as formal structures, personal networks emerged, through which teachers could obtain information without feeling anxious or incompetent.

Support must be planned for, but it must be flexible enough to serve a variety of needs at the same time. As needs change and new demands are made, so support structures must adapt, for it is only after attempts are made to implement change, that we come to understand more clearly what we need to know.

Teachers, like all learners, should be given the opportunity to make sense of change. Whether a philosophy of learning and teaching, or a technology-based innovation, staff must be allowed to experiment, to make mistakes, to explore and to discover. Structures need to be developed which allow for the free exchange of ideas and experiences in a supportive environment.

The initial motivation to participate in change may come from many directions, but a climate should exist where participants can feel that their involvement in the change has purpose and will provide benefits. To ensure relevance and a valid framework for change, the existence of a clear philosophy needs to be shared with those involved. Nor should the change or the philosophy be viewed as a static package which is to be "learned" or implemented. Meanings and beliefs need to emerge through experience and practice: they need to be shared and they need to be challenged.

Encouragement can take many forms but, as in a financial transaction, people need to be able to see a definite return for time and effort invested. Learning outcomes need to be monitored and recorded, changes in relationships and roles need to be discussed - and adaptation must occur as needs dictate. In this regard, the role of action-research is critical to ensure that theory and classroom reality support each other.

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OBJECT ORIENTED PROGRAMMING

TEACHING OBJECT ORIENTED PROGRAMMING USING EIFFEL AND SOFTWARE ENGINEERING TO UNDERGRADUATES

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Object Oriented programming is fast becoming the 'flavour of the month with industry'. Many vendors are selling products that now have object oriented attached. So, it would be reasonable to assume that most people are familiar with the basic tenets of the Object Oriented paradigm. Yet when students come to classes to learn about Object Oriented (O-O) programming they are not at all familiar with these concepts.

In fact most students express fears about abandoning their well known, tried and trusted procedural methods. What is it about O-O that makes it so different? This paper examines some of the major underpinnings of O-O in an attempt to explain what O-O is.

WHAT IS THE OBJECT ORIENTED PARADIGM?

To start with, let us examine a familiar method used to break a problem down for coding. That is the Top Down approach. The top down approach breaks down the problem to its lowest atomic level and uses techniques such as structure charts and pseudo code to represent this break down. How is Object Oriented different? Well firstly we must ask, what is meant by an object.

Meyer (1988) suggests that the objects are the things we want to model in our problem statement. Booch (1983) suggests that objects are the nouns from the problem statement. I will use an example to illustrate.

Say that we want to write a program to model a banking system. In our system we would have a bank, some accounts and customers of the bank who open, close and use the accounts. So in an O-O approach bank, account and customer would be the objects that we want to code. After deciding that these objects are going to be the basis of our program we might ask how are the details going to be stored. Should we set up some external files to hold customer and account details? No. In the O-O approach the data is combined with the method. So for example, the object bank when coded would have some sort of list structure embedded in it that held the customer's details. This list is not separate from the object but contained as part of it.

Note that technically what we are referring to as an object is really a class. So we have a class of banks, customers and accounts. The object is really a specific run-time instance of that class.

Now that we have some idea of what an object is, what else do we need to know about O-O. Booch (1991) lists four elements considered essential to the O-O model:

1 Abstraction
2 Encapsulation
3 Modularity
4 Inheritance

The rest of this paper will examine each of these four elements in turn, starting with abstraction. Abstraction is considered the most important because it allows us to break problems down into less complex parts thus making the overall problem easier to solve.

ABSTRACTION

When we use top down decomposition we are using a type of abstraction. For example high level boxes on a structure chart are abstractions that are simplified further down the structure chart. Each level that we go down in the structure chart becomes more concrete, that is includes more about the how.

What we want to know is what the class is going to do, not how it is going to it. The how is left to the concrete stage. What then relates the what to abstraction? The relationship is how the concept of abstraction highlights those things that we think are important and ignores everything else. This highlighting gives us an overview of the problem, thus making the entire problem more easily understandable.

The important thing then, is to decide what are the essential features of our abstraction and what behaviours they are allowed to exhibit. Let us use the bank example, and make the class account into an abstraction. We ask ourselves; what are the essential features of an account? The answer; each account must have a customer, identified by some unique number (account_number) and contain some money (balance). These features provide us with an abstraction of a general bank account.

We then need to enquire, what behaviours are these features allowed to exhibit. That is, what operations can be performed on account using account_number and balance? The operations that an account could use are: open, close, withdraw, deposit, and check_balance and interest.

This information is then combined to provide an abstraction of a bank account. See figure 1 for an illustration of our account abstraction. Note that no code is included at this stage, just the general outline of what an account might look like. In fact when the system is fully coded account may still be a fully abstract type with no code at all, (all operations deferred) or a partially abstract type with some operations coded.

```
Class Bank account
      variables
        account_number : number
      balance : number
      procedures
      open
      ....
      close
      ....
      withdraw
      ....
      deposit
      ....
     check_balance
     ....
     interest
     ....
 End class
```

Figure1

As account is at such a general level we may then use it as a template, later on, for more specific types of accounts such as Savings, Cheque, and Automatic teller. If we had defined it at a more concrete level at this stage, such reuse would have been very difficult if not impossible.

By itself however, abstraction is not enough, we need to ally it with other concepts (encapsulations, modularity and inheritance) to make a true object oriented model. Encapsulation strengthens the abstraction by allowing the implementation details to be hidden from the user.

ENCAPSULATION

Encapsulation is sometimes referred to as information hiding.
This is not strictly correct. Information hiding allows a module to keep secret all of its information. If any data is to visible externally then it must be explicit declared. Encapsulation is the process of placing all the relevant code modules for a class together.

For this to work though we must have two components to our class. One the interface for external access and two the internal implementation of the class. We can say that encapsulation allows us to hide how the class carries out its function, while providing enough information in the interface for the class to be used by other programs. See figure 2 for an example.

This dichotomy gives the programmer much greater freedom. For example, if at some later stage the implementation has to be changed then the change can be made without affecting other programs using that class.

Note that in figure 2 the method used to store and access accounts is internal to the class ie they are fully encapsulated. This technique means that external users require no knowledge of how the account is stored to access it. They just have to correctly use the interface to implement whatever method they have chosen to use. We have also deferred the implementation of interest until later as we do not know what type of account we have yet.

There is a problem with the use of encapsulation by itself however. The introduction of procedures and functions allowed for the possibility of partial encapsulation. The problem that appears with procedures is that they must allow access to the common data if they allow access to the procedures. As we have seen above, in figure 2, encapsulation allows us to hide the implementation details thus partially overcoming this problem.

If there were some way of grouping procedures so those procedures that accessed the common data could be joined together in some manner, we could solve this problem.

MODULARITY

Combining encapsulation with modularity provides us with the ability to group common modules into a single abstraction but keep the interfaces narrow. This links into Booch's definition of modularity as "... a system that has been decomposed into a set of cohesive and loosely coupled modules" (1991 p53).

```
Class Bank account
  * external view
        open (account_number, amount),
        close (account_number)
        check_balance (account_number),
        withdraw (account_number, amount)
        deposit (account_number, amount)
        interest (account_number)
  * internal view
    variables
      amount : number
      account_number : number
    balance : number
      accounts : list [number, number]
    procedures
    open (account_number, amount)
     insert (account_number ,amount, accounts)
    close (account_number)
      delete (account_number, accounts)
    withdraw (account_number, amount)
      if may_withdraw
            balance := balance - amount
      else
            write "account will be overdrawn"
      endif
    deposit (account_number, amount)
      balance := balance + amount
  check_balance
    check_balance := balance
  may_withdraw
      if balance > amount
           may_withdraw := true
      else
         may_withdraw := false
     endif
  interest deferred
End class
```

Figure 2

From figure 2 we can see that the methods such as open and close have been placed into modules which relate directly to the account class. In fact some of these modules, such as may_withdraw, may be completely invisible externally, and only available for use within the class itself.

So what we developed so far is an abstract model with methods that may be used but, with the implementation details hidden. A user could then code

`account.open(1234,1000)`

in the knowledge that this would access an account object with account number 1234 and a balance of $1000. What the user would not know and would not need to know is how the account was stored or where it was stored.

A little diversion could be of interest here. The above example serves to illustrate how a typical feature in a class is called. This fragment of code in some class has created an account object. We know that account has an external feature called open that accepts two numeric parameters. This is just like a procedure call. The client (class using the service) is passing a message to the supplier (class suppling the service) account asking account to fire up the feature open and use the two parameters passed to it. End of diversion.

Do we need to go any further then? Yes.
What happens if the user wants to open a number of different accounts?
Do we have to write a different program for each of the accounts that a bank has? No.

INHERITANCE

As mentioned previously we need to have some mechanism for sharing code when we create similar classes. Inheritance provides just the thing.
See figure 3 for an example.

See Henderson-Sellers (1992) for a more complete discussion on the above example.

When we analyse the problem completely we may find that all the above accounts are required. In our procedural code we would then have to write code five programs to handle each type of account. Using the O-O method we would use the existing code that we wrote for account in figure 2. This code could then be passed down to the 'children' for them to use or extend.

An important feature shown in figure 3 is the use of multiple inheritance. The class ATM inherits features from both cheque and savings. So ATM can use methods defined in both its parents, cheque and savings. This reuse of code is one of the major features of object oriented programming.

Another point to note is that as we go down the hierarchy from account to ATM the methods in the classes become fully coded. For example, interest would have to have some code before it could be used.

An example of how the class ATM might look is shown in figure 4.

In figure 4 the class ATM inherits features from both cheque and savings as well as from account. So that an overdraft facility comes from cheque and a PIN number comes from savings. There is another aspect concerning overdraft that is of interest. That is that the feature has been altered from what it was in the ancestor class.

This is part of the generalisation of classes that inheritance allows. If a feature is too restrictive at the abstract level the feature may be altered, whilst still keeping its integrity and interface intact. We can also note, that inheritance is a form of specialisation, where for example, a passbook account is more specific or not as general (abstract) as account.

SUMMARY

We have seen that the backbone of the O-O paradigm consists of four pieces. Each piece supports and depends on the other for the true functionality of O-O to appear.

Firstly, we saw that a model may be abstracted out to make it general. The important element to focus on at this level we noted was the what of the problem not the how. The implementation details come later.

Secondly, the concept of encapsulation was introduced. That is, the notion of a small interface with the outside world, as well as hiding how the program carries out its work.

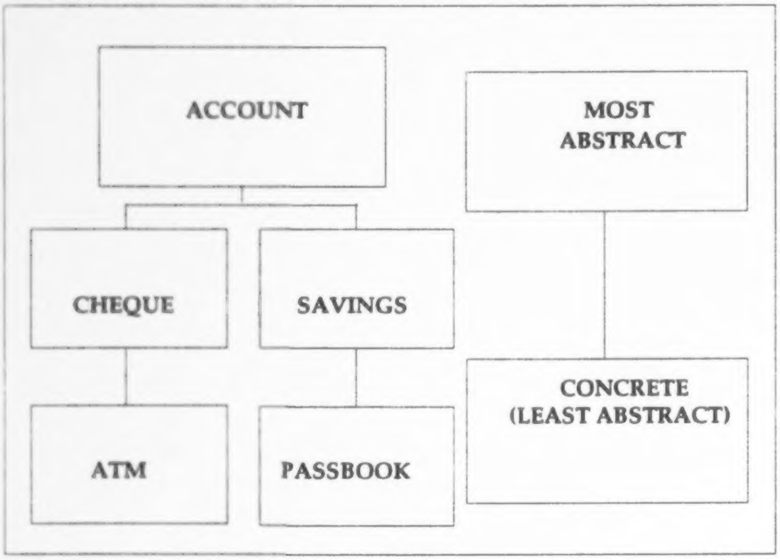

Figure 3

The third piece, which is probably the most familiar, was creating the class from modules the class. The important point here was that all the features relevant to a particular class were grouped together along with the data for that class.

The last component of our backbone, and perhaps the strangest, was inheritance. The important concept of a parent class passing down code for its sibling to use was introduced.

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```
Class ATM account
    inherit savings, cheque
   * external view from parents
           open (account_number, amount),
           close (account_number)
           check_balance (account_number),
           withdraw (account_number, amount)
           deposit (account_number, amount)
           interest (account_number)
           pin_ok (pin)
   * internal view
    variables
     amount : number
    interest_amount : number
     account_number : number
    balance : number
     pin : number
     overdraft_limit : number = 500
     accounts : list [number, number, number]
   * accounts has been extended to include pin number
    procedures
   * procedures from parent classes do not have to be rewritten
   * so just add new ones for this class
     pin_ok(pin)
           if pin = accounts.pin
                     pin_ok := true
           else
                     pin_ok := false
           endif

    interest (account_number)
           interest_amount := balance * .002
              add_interest (interest_amount)

     redefine may_withdraw
       if balance > amount + overdraft_limit
             may_withdraw := true
       else
         may_withdraw := false
      endif

    * another internal routine invisible to the outside
     add_interest (interest_amount)
           balance := balance + interest_amount
End class
```

Figure 4

COMPUTER SIMULATIONS: DO THEY HAVE MERIT?

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A number of papers on educational simulations and computer simulations were examined to establish current areas of concern. In this literature there appeared to be clear support for simulation only in the affective domain, though there was no conclusive evidence that students do not gain in a cognitive sense. An experimental research study was undertaken to determine if computer simulation results in improved cognitive performance. The result of a t test for independent samples showed no significant improvement in cognitive performance between two groups of students, one using a computer simulation and the other not.

The result of another t test did indicate that low ability students may benefit most from the incorporation of computer based activities in their learning environment.

Simulation is the artificial construction of reality. According to Maguire (1989) true simulation "is the process of designing a model for the purposes of describing, explaining and predicting the operation of *a* system" (p.111). Simulation does not reproduce reality faithfully, rather it makes simplifications that imitate. In a classroom setting, to aid the development and application of concepts and process skills, a pre-designed model is often presented, which means that educational simulations often mirror reality less closely than true simulations.

In any learning situation, the adoption of a particular strategy must be to the benefit students. Conolly (1988) believes students gain from using educational simulation because it permits them to reconstruct experience, reflect and apply knowledge. Educational simulation may promote learning in several aspects of the cognitive and affective domains.

In the cognitive domain these can include; the accumulation of facts and experiences, handling abstract concepts, learning procedures, sequences and strategies for thinking, and developing an understanding of general principles and process. In the affective domain simulation can motivate, alter attitudes towards teacher and subject, and enhance confidence in making judgements. According to Adams (1973, cited in Kistler, 1988), it is the capacity of simulation to unite the cognitive and affective that makes it a powerful technique.

Kistler (1988) says a considerable interdisciplinary research base has emerged on the impact of educational simulations. In reviewing this literature, Kistler found evidence (Dekkers and Donatti 1981) to suggest that while educational simulations were no more effective than conventional methods, they were a superior teaching/learning strategy as a motivator, a view that was supported by Taylor (1972) and Thiagarajan (1973). Other studies suggested the existence of more teaching/learning advantages; greater pupil control over learning processes (Broadbent, 1967), the provision of a flexible tool for teaching and learning (Harper, 1980; Heinich, 1985), the development of active student involvement (Bok, 1985) and transference of learning (Scriven, 1985).

COMPUTER-BASED EDUCATIONAL SIMULATION

Kistler's evidence suggests there is a place for educational simulation in the curriculum. However, with the infiltration of microcomputers into schools, a new question is being asked. Lunetta and Peters (1985) put it this way, "if we are to re-introduce the orreries of the past, now in computer-based form, it is fair to ask ... of this new medium, will it significantly enhance this old tool?" (p.31). They answer yes, saying the key element is the interactive nature of the computer. Shaw (1981) writing on the interactive benefits of computers, says interaction forces students into active participation in their learning and causes them to operate at a higher level of intellectual activity than is often achieved in more conventional learning environments.

As a tool, computer-based simulation appears to be well suited to problem solving activities, a view supported by Shaw (1981). Recent research has tended to highlight this advantage. Rivers and Vockell (1987, cited in Collis 1987 and Pollin 1989) used simulation to stimulate problem solving in science education. They divided students into two groups, one using computers and the other studying similar topics using conventional techniques. To measure students' problem solving skills, three content specific pre-tests and post-tests, the BSCS Process of Science Test, the test of Integrated Process Skills and the Watson-Glaser Critical Thinking Appraisal were administered.

The results of the post-tests showed no significant gains in content-specific knowledge as a result of using simulation software. The tests used to assess general problem solving though, demonstrated that students in the computer simulation group were developing more generalisable problem solving skills than the others. Based on this advantage, Rivers and Vockell hypothesised that evidence of transfer might appear as improved performance on future pre-test scores. This trend did emerge, suggesting that simulations can improve generic thinking skills and allow students to transfer them to novel situations.

Woodward, Carnine and Gerstein (1988, cited in Collis, 1988) using a similar methodology, found evidence to support the view that computer simulations can promote student problem solving ability. They assigned a group of students with learning difficulties randomly to two groups. A third group of regular students was used as an additional control. Both learning difficulty groups shared the same first half of twelve daily lessons but during the second half one focused on the diagnosis of health habits using conventional techniques while the other half used a computer-based simulation. In testing the groups on knowledge acquisition and health problem diagnosis, the learning difficulties simulation group not only did better than the group using conventional methods, but significantly outperformed the regular classroom group. While the results seem conclusive, Woodward et al. emphasise that it is not the computers that have most potential, but computers embedded within a framework of good teaching practice.

Grummitt (1980), conducted a study on secondary school geography students to test the hypothesis that "students taught by the computer simulation method would have greater measurable gains in learning than comparable students taught by the lecture and/or manual simulation method" (p.13). Data were gathered from a population of 70 boys in 4th year (Year 10) geography at a single sex school. Students were grouped into three homogeneous groups based on cognitive abilities testing. Using a pre-test, post-test and delayed post-test design, the researcher was able to identify a statistically significant difference, which favoured the Computer Assisted Learning group. Further analysis of the delayed post-test indicated that while computers in the classroom increased learning, particularly regarding processes, they did not necessarily result in greater retention of knowledge. Grummitt therefore qualified the results, stating that ideally computers should be used with other methods of instruction.

The organisation of computer-based simulation within the learning environment has been a catalyst for research. This was the case in two studies reported on by Bracey (1988). In the first study (Johnson, Johnson & Stanne (n.d.)), the researchers used three groups of eighth grade students to interact with a computer simulation that taught the fundamentals of navigation. The first group, "the co-operative group", was informed that each member's grade would be derived from an average of all the students and that bonuses would depend on group performance. The second group, "the competitive group", was told their grades would be determined from a comparison between students and that bonuses would be given to students who finished first. The last group, "the individualistic group" was to have their grades and bonuses determined solely on individual performance.

Johnson et al. assessed student performance on two aspects; the number of worksheets completed and results on a final exam. On number of worksheets completed, students in the co-operative group completed the most, while students competing amongst each other, completed the least. On exam results, co-operative students did best on factual questions and better than individualistic students on questions requiring them to solve problems. The study also found that girls in competitive situations fared worse than boys and developed poorer attitudes, a situation that did not manifest itself in the co-operative setting.

In the second study, Bracey (1988) reported the findings of research (Mevarach, Stern & Levita, 1987), that considered questions related to co-operation between students using computers. In this example, one-third of the students used a simulation alone, while the other two-thirds were grouped in pairs for the simulation. The study noted the development of strong bonds between partners, while the partners' relationships with other class members remained unchanged. Favourable attitudes towards co-operative learning also developed in the paired students and while not statistically significant, the paired students outscored the others on achievement tests. As a result, the authors were able to conclude that small-group settings can improve social orientation, without producing negative impacts on achievement and attitudes.

Stead (1990) is one researcher who has attempted to define the limits of computer simulation. Based initially on observations of student performance in the simulation, *Running the British Economy 1987*, Stead identified two factors, time pressure and the element of the unexpected as limitations that result in students keeping erroneous ideas about what the simulation was attempting to achieve. The study concluded that simulation would support learning best when it facilitated the integration of feedback from the simulation with existing knowledge. Failing this, simulations should be structured to give students time to reflect on and discuss the data presented and that some framework is needed to facilitate these activities.

Under the research microscope, the effects of computer-based simulation appears to be superior to conventional teaching in the affective domain. On the cognitive side, however, the positive impact appears to be a less apparent and favourable results are often qualified. It is therefore not altogether clear whether students engaged in computer simulations learn more effectively than do students engaged in traditional teaching approaches. To address this question, a small study was conducted to examine whether differences in achievement on test scores exist between students whose learning experiences involve computer-based simulations and students whose learning experiences do not involve computer-based learning. The study used an experimental pre-test-post-test control group design to measure the effect of an independent variable, computer simulation - on student achievement.

In order to keep the study manageable, it was decided at the outset to accept that motivational and attitudinal gains exist from incorporating computers and simulations into the curriculum (Bramble, Mason & Berg 1985; Scriven, 1987; Bracey, 1988; Magney 1990; Roblyer 1990;).

METHOD

SAMPLE

This study was completed using the resources of one school, a comprehensive high school located in Sydney's western suburbs, drawing students from a largely middle class population that has an established migrant background. The subjects were 87 Year 9 Geography students. As some students were absent at critical times, 78 completed the study.

CHOICE OF SIMULATION

The computer simulation *Village* (Payne, Hutchings, & Ayre 1980), was selected for the study. This choice was initially influenced by; the teaching/learning programs used to implement the syllabus in Geography for Years 7 to 10 (N.S.W. Department of Education, 1983) and the availability of computer software to satisfy syllabus objectives.

Village models the decision making involved in selecting a site for a settlement. Students are given data on a method for calculating optimal locations for settlement in about 600 AD. - this being a period in which such an activity would have been undertaken and when the variables to be considered would necessarily be limited to the availability of water, grazing and arable land, fuel and building materials. The simulation recognises that siting a village is a compromise between the relative location of resources. Students make selections based on information presented to them and the simulation quantifies these and labels it an efficiency score.

To promote informed choice, the simulation provides data on resource availability before students elect to select three sites for a village. Another opportunity is then offered as a means of evaluating the initial choices. Next, the simulation presents data on how to calculate the efficiency score used to determine which locations are optimal sites. Two additional opportunities to improve the site of the village are then presented. In the final stage, the simulation asks students to consider the defence of the village. No guidance on the effect of defence is given, instead students are asked to develop an understanding of the relationship between defence and site efficiency by selecting another five sites.

The type of problems presented and the range of possible solutions suggest that *Village* is an example of a resource allocation exercise (Edens and Gredler 1990). Resource allocation exercises present a structured problem requiring students to engage in higher order thinking. Learners must apply certain principles appropriately and it is the combination of particular principles that constitutes productive thinking and understanding of the interplay of choices. As a result, students should be able to apply principles in novel situations more readily than if the principles had been learned within a restricted context.

While theoretically sound in it's development and application of concepts and process skills, the original version of *Village* contained a number of deficiencies that were embodied in a lack of user friendliness. Attempts to improve the sophistication of the program, occurred through modifications to the original source code, though these were limited by time and the researcher's expertise. In short, data was better structured so it could be presented in meaningful screen chunks, and limited textual graphics, were added.

INSTRUMENTS AND LEARNING ACTIVITIES

In order to assess the effect of computer simulation on student achievement., a criterion referenced test was developed, to be used as a pre and post test, by the researcher with the assistance of several teaching colleagues and evaluated before implementation. An instrument which had been validated and considered reliable, was not available.

The test consisted of a combination of short descriptions and one word answers. A pictogram of a hypothetical region, containing information about site and situation factors was used to elicit student responses to the questions. Questions were designed to assess the acquisition of the geographic concepts of Location, Movement and Interaction, at three cognitive levels; knowledge, application, and analysis and were constructed following extensive trialing and evaluation of the computer simulation. The choice of pictogram over maps, represented an attempt to structure the test more to application and analysis than knowledge, that is, to promote generic thinking skills and the transference of learning (Rivers & Vockell, 1987, cited in Collis, 1987; Scriven, 1985, cited in Kistler, 1988).

Three sets of criteria for marking the test were developed, one by the researcher, one by the teacher of the non computer (control) group and another by the head teacher in Social Sciences. After consultation an agreed set of criteria were established and used to mark both the pre-test and the post-test.

Four, forty minute lessons were then prepared, two lessons to identify site and situation characteristics of settlements, and two that involved a given set of pre-defined characteristics to determine the best location for a settlement using either a computer based simulation or a pencil and paper activity. In lesson one, both groups were given a definition of site and situation, along with an example - Sydney. They were asked to complete a mapping exercise that re-inforced the two concepts. In lesson two, both groups were asked to apply their understanding of site and situation to a novel example of a camping site. To keep instruction and materials as similar as possible, the same lesson outlines were used in lessons one and two, In lessons three and four the computer group completed a computer-based simulation, and the non-computer group a pencil and paper activity. The same lesson outlines were used, adjusted for the differences in presentation.

The rationale for four lessons was based on research on the effectiveness of computers in the secondary classroom. A meta-analysis by Kulik, Bangert and Williams (1983, cited in Fitzgerald, Hattie and Hughes, 1985), found that students using computer assisted instruction outperformed the average student in traditional classrooms when the computer was used for short periods of time - four weeks or less. Samson, Niemiec, Weinstein and Walberg (1985, cited in Collis, 1986) presented similar findings to the American Educational Research Association, though they stated that two weeks or less was more beneficial. The split between conventional and computer assisted learning techniques arose from the work of Hartley (1978, cited in Fitzgerald et al. 1985), who concluded that students gained more when the computer was used as a supplement to rather than a replacement for traditional methods, a view supported by Woodward et al. (1988, cited in Collis, 1988).

PROCEDURE

Four weeks prior to introducing the simulation, students were given the pre-test. Upon completion of the pre-test, test scores were rank ordered, and students paired from highest to lowest before being randomly assigned to one of two groups. All the tests were marked by the researcher. To ensure validity, a sample of 9 tests, 3 per class, were randomly selected and doubled marked by the teacher of the non-computer group. The group to complete the computer simulation - the experimental group - was then determined by toss of a coin.

Students were asked to work in peer selected pairs or three to complete the activities. This served twin purposes. Firstly, research evidence suggests that students gain more when in group situations that involve either computers or simulations (Leong 1981 cited in Fitzgerald et al. 1985, Bracey, 1988; Lidstone, 1990;) and secondly the number of computers available in the computer laboratory, was limited. To minimise the impact of gender issues (Bracey, 1988.) single sex groups were established. To minimise mortality, groups were formed at the beginning of each lesson.

The pre-test was given a second time as a post-test. This was done in the first timetabled lesson after the treatment. Students who did not complete the pre-test were post-tested if present, but their results excluded. No attempt was made to test those students who were present for the pre-test, but absent on the day of the post-test. Furthermore, the scores of two students who sat the post-test but did not complete the simulation activity were also omitted.

RESULTS AND DISCUSSION

The means for the computer (experimental) and non computer (control) groups on the post-test were 18.69 and 18.75 respectively. The difference of 0.06 was found to not be significant on a t test for independent samples, t (76) = 0.055, $p < 0.95$. This suggests there was no identifiable difference in the group's scores that could be attributed to participation in the computer-based simulation.

Means for pre-test scores for the computer and non computer groups were calculated at 11.49 and 11.69 respectively. The differences between both group's pre-test and post-test means would appear to suggest that each group did learn from their involvement in the study, supporting the view that well planned teaching strategies do result in significant student achievement (Hartley 1978; Woodward et al., 1988, cited in Collis, 1988). Furthermore, it would suggest that simulations, whether they be computer based or use pencil and paper techniques, can promote effective learning. The addition of a third group to a study would have been necessary to provide substantive support for this viewpoint.

Indications that each group improved by a similar amount, raised concerns about the quality of *Village* as a computer-based simulation. In discussing the operation of the non-computer activity, it became apparent that students used hand held calculators to complete computations. It would appear then, that the modifications to improve the sophistication and user friendliness of *Village* were more cosmetic, and that the pre-designed model in *Village* did not utilise the computational power of the computer, when compared with other classroom technologies. Future studies should therefore be aware of both the development of students' computational skills and the technology available to students and use simulations that require more complex skills or involve the manipulation of a far greater number of variables, views supported by Howard (1987) and Hodson (1990), although the number of variables and the time required to complete the computations needs to also be considered (Stead 1990).

Although not initially part of the study, research findings by Burns and Bozeman (1981, cited in Fitzgerald et al. 1985) and Samson et al. (1985, cited in Collis, 1986) suggest that less able students improve significantly more on test scores as a result of learning experiences that include computers than more able students. To examine whether the effect was present in this study, the pre-test and post-test scores of the students from the lowest academic Geography class in Year 9 that completed the entire treatment (13 students) were isolated from the scores of students in the other two academic classes (23 students and t tests completed on the pre-test (t (34) = 5.03, $p < 0.0001$) and post-test (t (34) = 1.62, $p < 0.1141$) scores. A significant difference between less able and more able students did exist in the pre-test results, which subsequently disappeared on the post-test. This would appear to suggest that the *Village* simulation helped the lower achieving student more than the high achiever. This result, however should be interpreted with caution because of the size of the samples involved.

If computer-based simulations are to be used in schools, then some guidance as to what to look for in a good simulation is required. Teachers must ensure that once a computer-based simulation has been deemed satisfactory it is integrated into good teaching practice and that through thorough evaluation the relevancy of the simulation is monitored with respect to student skill levels and the range of technologies available to students. As Lunetta and Peters (1985), Ragsdale (1982) and Watson (1982) point out, if education is to use new tools in place of the old, then the new must result in an improvement of the educative process.

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UBIQUITOUS PERSONAL COMPUTING - CAN WE 'SEE' HOW IT'S DIFFERENT?

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In this paper I try to identify some aspects of computing with personal, portable, notebook computers which are not available in situations where only desktop computers are used. In many cases, there are so many similarities between desktop computers and notebooks, eg the hardware specifications might be the same, that we overlook (or fail to recognise) the differences. Often what is missed is precisely what is sought by many of us who are using notebooks.

INTRODUCTION

In 1990 I was working on a Logo program with a QSC1 teacher who wanted something which would determine if his students (11 year-olds) had correctly transformed algebraic expressions. I suggested he could use Logo to develop a set of 'algebraic scales' which would show the equivalence of two expressions and then let the children use the programs on their notebooks as they played about trying to solve their equations. At the time, the idea of 'computer as beam balance' was novel. Over time, it has become the basis for many interesting activities in his mathematics lessons.

Two years later I was in an audience to which this teacher (Mitchell, 1992) was demonstrating his latest computational toy, what he called his 'open calculator'. Every child in the class he described had a personal, portable notebook computer which could be used where and when the child chose.

> **The speaker explained how he and his children construct algorithms in their notebook computers and use / adapt them for many different purposes as they work their way through the mathematics curriculum.**
>
> **One man in the audience questioned what the children were learning.**
>
> **For a few moments, the speaker was tossed.**
>
> **He recovered and struggled to say that they were learning to organise themselves in the solving of problems, that they were participating in the classroom culture in different ways, that children who might have been classified remedial were working hard and long and 'getting there', even setting higher standards for themselves.... He explained how the children often borrowed procedures from each other or from another context in which they had used them, ...**
>
> **The original questioner was getting frustrated.**
>
> **He had asked a good question and he, along with many others in the audience, was waiting for the answer.**
>
> **The questioner was concerned that programming was becoming the focus of the work in the classroom described and that mathematics was no longer being done as he thought it should be. An 'interesting' debate arose: the classroom being described was one in which all children had been using their own notebook computers for two years and in which programming was accepted as just another form of expression. Were the sorts of difficulties they had equivalent but not in excess of those they might have had using English...**
>
> **But the speaker was trying to draw attention to something quite different.**

The differences between the classroom being described, and those from which most members of the audience came, appeared too large for immediate effective communication between the teacher referred to and those in the audience. It felt to many as if the speaker 'had missed the point', lost the plot.
I became acutely aware of the lack of *dialogue* between the audience and the speaker, and wanted to work on the 'technology' of the situation, what I call the awarenesses, the ways of speaking and thinking, in the circumstances.

I was sitting in the audience with a colleague: we were comfortable. I was familiar with the classroom being described and he with this kind of teaching/learning in the context of ubiquitous computing. We felt empathy with the teacher and at odds with some of the concerns of others in the audience. We were lost. What was happening? *Were we , as the audience, split into two groups, each imagining different types classrooms or were we just attending to different aspects of the same classroom?*

This experience focussed me again on some important issues:

- How can we learn to see things differently?
- What it is that we see when we do?

and

- How do we evaluate what we see?

and

- If we knew the answers to these questions, how would that help us in our work.

Perhaps a subsidiary question is:

- How can those who are working in the way described share their experiences with others in order to let the others evaluate vicariously what they are doing, and how the children are responding?

NOTEBOOKS FOR A CULTURE OF FORMALISING THE INFORMAL

Last year a team of senior educational policy makers visited another classroom in the school described above[3].

The children were working on mathematics and had written procedures to use a random number generator for some activity. The visiting Mathematics person suggested that as a mathematician, he would like to know how often 6 occurred as one of the random numbers. "Out of how many turns?" the child asked. Within a couple of minutes there was a procedure which recorded this data in addition to whatever was being done with it before. The mathematician went on: in one hundred turns? in one thousand turns? .. in fact he would like to be able to use a general procedure with which he could choose how many turns and get the number of occurrences of 6, or 4, or 2, if he so chose. He went off for coffee.

When the adults returned to the classroom, a number of children were observed to be working on their generalised procedures and busily investigating frequencies and making comparisons between their data and that of others.

The classroom was now populated by a new generation of children in their first year with notebooks (the teachers were in their third year of teaching with notebooks).

What was reported as having amazed the visiting team was how well the individual children, now asked to explain what they were doing, could flip to the formal imperative expression of the problem, now in its generalised form but originally used in a special form, and with confidence show the visitors how they had built up their programs.

These children have all used LogoWriter as their base-software before widening their repertoire of computing skills to include a staggering range of applications. They have learned to 'speak' Logo programming language. They have to think carefully when they add ideas to their notebook files because in LogoWriter it is necessary to classify the new information, to make decisions about the structure of what they are accumulating as they write their ideas into formal language. Working with LogoWriter is not so unusual, so are these children different in any other way? The work referred to was done in their recess time, it was done by as many children as heard about the problem, not only those who were set the problem, it resulted in many different, idiosyncratic versions, each to match the particular procedures the child already had within their notebook, and it was done for fun. Perhaps it was done partly because 'that's what everyone is doing'.

I would suggest that *the culture of that group of children supported the formalising of the informal* (the writing of Logo procedures in this case) when in other classrooms, children might have dealt with the challenge in quite different ways. I would normally expect to find the visitors or teacher stimulating a few children to work on the challenge in classtime, but in the children's culture described, working on problems was the way of life. The culture was not dependent on the teacher or the classroom but belonged to the children and their notebooks.

But how many of us see, in the story above, an example of children working from the special case to the general? How familiar are we with the idea that young children can behave mathematically, using formal expression of ideas to develop generalisations? How often do we see this sort of behaviour spontaneously arising in school yards? Is it any wonder we find it hard to recognise?

NOTEBOOKS FOR ENTERPRISING LEARNING

The Australian Commission for the Future has worked hard with the expression 'enterprising education'[4] to develop an awareness of the possibility of being enterprising by working in such a way as to have more hands making lighter work of a given task. If one teacher is struggling to give 30 children the particular experience they need on a particular day to gain insight into some aspect of geography, to awaken their awareness of a possible shift of attention, the poor teacher is really working hard. If, on the other hand, there are 31 people in the room with the goal that everyone in the room will have such an insight, it is possible to employ the energy of all those people for the task. Whose problem is it, after all?

The teachers in the classroom described above work hard at 'being enterprising'. Originally it was hard for them to let go of what they saw as their responsibility and rely on the children to pass ideas around the classroom community but after an initial period in which they were deliberately forced into adopting this stance, because they could not cope with 60 children and 60 notebooks 'dumped' in the room, these teachers gained faith in their fellow workers in the classroom and there is now *a strong sense of shared responsibility for learning*, at least with respect to computing equipment.

The notebooks helped in two ways: first, having suddenly to cope with this outrageous act of the Government and finding they could, provided a shared experience on which the teachers have drawn many times, and second, the now available computers made it much easier for the children to work together, to help each other.

The idea of having children working in groups is not new but in this classroom the children were able to go further than usual. A distinction can be made between working together, when tasks are shared, and working collaboratively, when minds are shared. For instance, if children are able to take a disk of work from one computer and *legitimately* place it in their friend's computer and copy the work, they may simply be making a complete 'project product' by reassembling pieces worked on by others but they may actually be working on pieces already worked on by their colleagues. The latter process may or may not be supported by a classroom ethos that the more that travels around the classroom and is shared the better[5].

Copying thus can take on a new dimension. Cheating and copying look the same from one perspective, but opening up the possibility of copying as a form of sharing, as one way to work more openly and collaboratively, has brought new possibilities to the classroom. Passing around notes, procedures, ideas happens very naturally in notebook classrooms where it is valued and saves a great deal of time. It happens without the need for centralised organisation of distribution, and so on. It would not be so easy to do, one suspects, without computer disks and notebooks constantly present to receive the offering.

Copying is not the same as cheating: but the differences are not as obvious as the form they take. Copying within a computer environment happens both when one receives and incorporates someone else's work, and when one brings to operate in one context, work one did in another. 'Cheating' can take several forms too: working together on an idea, sharing an idea and its expression with someone else is cheating or otherwise depending on the circumstances; taking a copy of another's expression of an idea and passing it off as one's own is cheating, but that is not new to our culture[6], and taking work done yesterday and making it part of work done today - is that cheating? This last activity is one which appears to be contributing to the process of adding quality and meaning to students' work in significant ways.

But *assessment* of individual's work is challenged by all this. Many original contributions are immediately stripped of time and author identification, and so teachers have to think again about how to increase their awareness of the contribution being made by each student. Similarly, if the work of students who are not coping is disguised amongst a group product, how could a student with a problem be identified? The QSC teachers and others have found that part of the solution to these problems lies in working more closely with students. They started to spend more time with individual students, up to half an hour at a time, instead of merely addressing them from somewhere in the room and assessing their work by evaluating 'chicken prints' on paper. This practice need not mean 'neglecting' other students in the classroom, given the learning culture described. What is done with one student can start to find its way around the community when the teacher moves on to work with another student. And the experience of spending significant amounts of time with one or two students makes an enormous difference to the relationship between that student and the teacher. It does not need to happen very often to be effective and thus, all students can get their turn and the teachers get to know how they were working.

Assessment in the QSC became more meaningful as students and teachers worked together on what was being done by the students. It started to be broadened to include aspects of classroom work which had hitherto been unrecorded, such as strategies used to learn, ways in which children supported and used their peers, etc.

There were a number of children in the class who were there 'just to see how poor achievers would cope'. They have disappeared. Mostly they are not poor achievers any more. He reported that often children who had 'completed' work and had it assessed would return to it and do more. He found that the children who previously were 'no-hopers' were even more likely to do this than the others and that, for the first time, they would have the satisfaction of completing their work at an acceptable standard - and this would be done even if it happened after the assessment had taken place!

Sometimes, it has been reported, the students actually have to explain to the teachers what they had done and why it was a good way to do it. Quality assessment is able to replace quantitative assessment.

There is yet another aspect of all this. If students are trusted to 'teach' and learn from each other, some of the more routine computing tasks can be taught to those students who might otherwise be known within the classroom as poor learners. These children can then re-establish themselves by acting as experts with new technology. The teacher being challenged in the presentation (described above) noted:

What did the notebooks contribute? The need to have 'experts' who knew how to do 'this and that' was a contribution, and also the fact that work was never complete and always at hand.
In most computing environments, students have to finish their work by a certain time for assessment purposes and after that, their 'computer time' is used for the next task. Students with their own portable computers have two advantages in this context: they can return to work so that they can *learn over time what was taught in time* and they can work beside their computers, with them shut or open, without feeling that 'computer time is not being well-spent'.

NOTEBOOKS FOR UBIQUITOUS, PERSONAL COMPUTING

At another school[7] in which all the students are acquiring notebook computers, the teachers were all 'encouraged'[8] to get one for themselves. The expectation was that these teachers would use word-processing and think about using subject-specific software for teaching purposes. They broke out of this mould very quickly and were 'discovered' to have many other uses for their computers. This happened with amazing alacrity and they were asked a few questions in order to ascertain what was happening.

It seems that the secret to this *eclectic computing* was related to the ubiquity and the personal nature of the notebook. The reasoning seemed to be, "If I own it, I should find out how to use it, and if I want to learn to use it, why not take it to the football?"

'Ubiquitous, personal computing' - quite an expression to unpack!

It has been shown that once a notebook computer is available, there is a tendency to pick it up and to explore what it can do. We now expect teachers to be using spreadsheets, for example, soon after they master the first level of word-processing (in Works) if they are able to discover the necessary skills at home. Why? We don't know, but suspect *the convivial nature of notebook computing* has something to do with it. The tapping of keys is very annoying to those not doing it but the pleasure associated with physical presence of a friend or member of the family seems to mitigate this. Notebook users report using their notebooks at times and in places where previously they would not have been able to 'work': work seems to have changed its nature and location.

This operates well for children too. Parents who want to 'supervise' homework have found themselves shut out by desktop computers (often unable to understand what is being done and disliking the physical aspects of the process). When students take their notebooks home and can be in the family room working, the parental anxiety seems to be eased. In fact there is more to this. When students can take their work to their parents, to their neighbour, or to do at a friend's place, the conviviality aspect again becomes conspicuous.

It has been reported a number of times that it is easy to carry a notebook to someone to get help and that this encourages the seeking of help. It is contrasted with the process of trying to get someone to come and help, which is described as a demanding process and often avoided.

But there is still more to it. We have reports now from many using notebooks who describe their notebooks in terms which previously might have been associated only with humans or animals. They say they will 'sit down with their computer and do some work' and seem to imply something akin to companionship is offered by the computer. It assumes a personal nature to such an extent that it provides company and can foster a new attitude to working. *'Computing' in this sense is more than 'doing work'*.

At the girls' school, the mathematics teacher had been working for several years on computer management of the students' compulsory mathematics when the notebooks started to appear. He was able to give students disks which would set them tasks according to their performance and provide them with challenges to test their achievements. His programme had been designed to divert energy from the management of this aspect of the students' work to helping those in need. What happened was not predicted. When the girls were freed from the bonds of the classroom computer, they chose to do their skill-development work at home in order to be free to work on interesting problems with their friends.

I was having a lot of trouble with my modem. I could not get it to work and when someone else showed me how they used theirs, I could not understand what they were doing. I did not really *need* to use it, after all.After I had spent a weekend with my colleagues and we had all struggled to solve the clues of the treasure-hunt, found on disks nailed to trees, buried in a fur-ball in a tree-truck, and so on, I felt prepared to try anything with my colleagues. I had a new sense that working together would make it possible to do what I could not do alone. I made an appointment to spend some time with someone else who also couldn't use a modem: we'd work it out!

Now I know that two minds can be so much better than one I am more confident about letting my students work together.

Classroom time was recovered for social construction of mathematics.

What seems significant about all these stories is the way in which the social nature of learning has been supported by the use of notebook computers. Contrary to the fears many of us had that we were approaching an era when studying would be synonymous with 'having a green glow on the face', we are finding scope for further development of the 'useful' social attributes of the mathematics classroom.

NOTEBOOKS FOR A COLLABORATING CULTURE

The 1992 report of the Apple Classrooms of Tomorrow (ACOT) programme in the United States claims that strong collaborative-working conditions are essential for innovation within the classroom. We have been investigating this issue in notebook classrooms for some time and have similar feelings. We have been paying particular attention to the need for collaboraion among those adults responsible for students with notebooks.

We believe it is *trust* to which the Apple evaluators were alluding. If teachers cannot take risks among colleagues, students among students, without fear of *failure*, there is little chance that new things will be tried and none that there will be opportunities to learn from failures[9].

In the classrooms described, 'having to cope with invading notebooks' helped alert us to the need to develop a trusting atmosphere within the culture. Once having achieved this, it is fairly easy to use it to advantage when working on the main learning curriculum.

AWAKENING AWARENESSES IN THE PRESENCE OF NOTEBOOKS

The motivation for this paper came from the experience of finding myself alienated by having what seemed to me like a richly embroidered image of what other people seemed to be seeing as impoverished.

After working with notebook computing in one form or another for a decade it is not surprising that we have a large collection of stories and that when a story is told about students with notebooks, many other stories come to mind which enrich the image. But what brings my stories to mind, what triggers my awareness of certain aspects of classroom interaction, does not do the same for others.

First we have the problem of how we have generalised from our experience. We, in Sunrise[10], have started to discern threads which we now label as collaboration; enterprise; personal, ubiquitous, and so on, but we recognise that we do not always find resonance in others. We suspect some of the threads we are finding will prove ephemeral, that others will become so common as to be transparent in a short time, and so on. So how can we work on the process of refining the generalisations at the same time as making them more accessible to others? Second, what can we do with new-found awarenesses?

The first problem has led us to try disciplining our work on experience in order to find ways in which we can share our experience with others but make it possible for them to use their experience to work collaboratively with us (Nevile, 1993) and the second problem stimulates our work on rehearsing the use of our awarenesses, making them actionable by preparing for them.

A teacher remarked that $ for $ the students' parents could do better than buy expensive notebooks for their children, and the parents are smart, so they will discover that!

CONCLUSION

Finally, it might be worth drawing attention to how little has been said about the notebooks, their make and model etc. It is various attributes of their presence which seems to make enormous difference to the opportunities available but they, as objects, do not so easily catch our attention. I wonder about this.

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ENDNOTES

1 Queensland Sunrise Centre at Coombabah State Primary School
2 one way of describing a preponderance for programming
3 this story was related to me
4 originally taken from the Plant and Ball OECD Report.
5 not a new idea that computing can be more easily undertaken collaboratively than other activities, but vastly accentuated in this context of ubiquitous computing
6 the Common Law has traditionally dealt with this as 'passing off' and in several centuries found the only way to decide what is happening is to consider the particular circumstances in each case
7 MLC (Melbourne), a private school for 2000 girls
8 financially and otherwise
9 MLC staff report an abundance of opportunities to learn from failure having appeared since they got the notebooks!
10 especially in the Sunrise Research Laboratory at RMIT

SUNRISE AND THE LURE OF EXPERIENCE

BY LIDDY NEVILE
Sunrise Research Laboratory, RMIT

Ursula Franklin (1990) writes:

Technology is not the sum of the artefacts, of the wheels and gears, of the rails and electronic transmitters. Technology is a system. It entails far more than its individual components. Technology involves organization, procedures, symbols, new words, equations, and, most of all, a mindset.

I write here about the process of 'disciplining experience' which is making our Sunrise programme a 'learning organisation' (Senge, 1990). We use the word 'technology' to mean awarenesses and ways of thinking and working with computers, mixed media, etc.

The paper is written in order to explore what is for the writer a continuing puzzle. A particular set of experiences preceded a particular development in some cultures (described below).

Making sense of that experience is not easy. It is not an experience one wants to replicate from one point of view, but the resulting culture is one which one would like to be part of, to see developing in other places perhaps. Is it possible to learn from the experience? Is it possible that what was found to exist after the experience was in any way related to it? Would the same 'product' have been observed if the 'experience' had never been had? or had been different? More generally, what can we do with experience and how do we know?

INTRODUCTION

> **In 1989 three teachers and their 60 ten year old children found themselves being surrounded by technological objects[1]. Each person was given a notebook computer and there were some goodies for the classroom; a scanner, cd/ROM, TC Lego, printers, modems, plotters, etc. This was a shocking act and left the teachers, soon to be supported by a project officer, with the massive task of making sense of all this nonsense.**
>
> **Three years later those teachers and children have been acclaimed as having not only 'coped' but often are regarded as exemplary models of 'successes' within the field of educational technology. They have conducted workshops and been asked to consult for others locally, nationally and internationally.**

I tell this story as I believe it to have been: there was what could most appropriately be described as an 'abusive intervention' in the lives of those people. But today, I believe, none of them would choose to not have had the experiences, well, to have gone on as they were and not be doing what they are now doing.

What I find puzzling is what is sometimes said about what happened, or rather, what we all seem to want to say about it.

> **The teachers and project officer worked to develop a classroom culture in which computers did not dominate, in which they could use computers as they chose for a range of uses but in which 'computer use' was not the main criterion for success, ... The teachers and children became technically very competent, knowing between them a great deal about managing the computers for which they were responsible as well as how to program them, ... The curriculum changed significantly and started to make effective use of the children's new-found skills, ...**

These facts seem to invite apparently obvious comments of the type:

"teachers need a good understanding of the features of a culture which will support convivial use of computers and the technical competence if they are to be able to manage an abundance of resources".

This often seems to be followed by a comment of the type:

"they should be trained to use computers and helped to understand the right cultures **before** they are subjected to the delivery of all the computers. That way the pain can be avoided and more can be achieved."

Such statements, which at first seem so natural and acceptable, are, in my opinion, dangerous.

Statements like these are easy to offer when advice is sought. They lead those seeking the advice to certain actions which seem very sensible. Those following this kind of advice often find no reason to question it. If they ask why this advice is likely to be useful, it is easy to get an answer which suggests that the advice is based on the experience. In fact it is not: it directly contradicts it.

What happened was that some teachers struggled and emerged triumphant. That is all the evidence we have. We do not have any evidence that some teachers who did not struggle succeeded, or that some who were trained .....

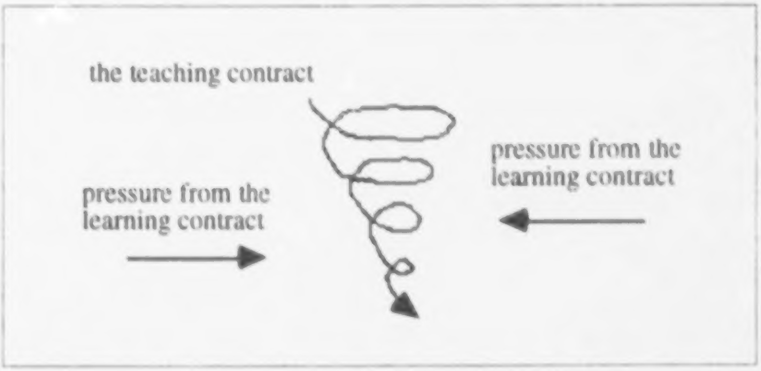
Another interpretation of what has happened to the experience, is that those observing have noticed that after a painful and exhausting experience, some lessons have been learned[2]. Such people might like to believe that the lessons can now be transmitted directly - without the pain.

Either way, we find that not much is being learned from the actual experience.

In this paper, I use this as an example of the way in which we can ascribe generalisations to experiences without taking sufficient care and in fact, soon enough find ourselves depending on generalisations which are not supported by the very experience from which we claim to have derived them. Another fine example is provided by the way in which we tend to accept the generalisation that girls do not like using computers as much as boys and then inadvertently take action which confirms this statement (see for example, Hoyles (1993)).

A-TENSION!

French educationalists (Brousseau, 1984) speak of the 'contrat didactique' as one in which the teacher has the responsibility of teaching and the student has the responsibility of learning. This contract can be seen to raise interesting questions: surely it is most efficient if the teacher tells the students what they are supposed to do and how to do it? This will save the students the agony of working through masses of hard exercises in order to extract what it is they need to know and it will save the teachers from having to battle with lots of work which the students do badly. Surely it is better for the students to experience success than failure? to practice what we want them to do and not to be distracted by things we do not want them to do?


the teaching contract
pressure from the learning contract
pressure from the learning contract

Building on this idea, Chevallard (1985) writes about the 'didactic transposition[3]'. According to this notion, something which is to be taught is dealt with by the teacher in such a way as to make it more appropriate for the students and this somehow involves actually changing what it is that is to be taught: a complex problem broken into smaller problems is not a complex problem. If we have the intention of having students understand a complex idea, why not break it into small parts so that they can make sense of the various bits and then they can synthesise the bits to develop the idea? If we follow this course, there will not be any big ideas too big for the students to cope with, everything will be manageable and so better?

This notion is often taken one step further too: innovations are pretty hard to cope with (see Hoyles, 1992). The transition from the pre-computer classroom to the computer-rich classroom, for instance, is a huge one and if it is to be accompanied by the development of a technologically-rich[4] culture, those involved are going to have to cope with an enormous amount of change. Surely it is better to anticipate what is going to be required, to make incremental changes, and thus to avoid the unnecessary confrontations which will otherwise result?

"Wait!" I say in response to all this. "What do we know?"

LOOK WHERE I AM POINTING NOT AT MY FINGERS

The teachers in the description above *did* cope with the circumstances in which they found themselves and *have* found the ability within themselves to thrive in testing circumstances (as do most teachers). Possibly they did *suffer* the experience in the sense that they had to bear it, to endure it, but possibly that is precisely what made it possible for them to achieve as they did.

I am not trying to argue that everyone should suffer (feel pain) as the teachers did, even that anyone should, but rather that without good ways of interpreting what happened, we run the risk of making decisions about how to streamline the process and make it more palatable and in doing this, inadvertently 'throw out the baby'.

One thing we seem slow to learn from experience,
is that we do not necessarily learn from experience.

It is my concern in this paper to focus attention on ways in which we can work effectively and validly with experience. It makes a lot of sense to work at practices which are effective so as to be able to use them when another opportunity arises but we have to be careful not to let them just become 'forms we fill', to develop formulae for practice which we use without thinking. Preparing for our future practice so that it will be 'informed' is not the same as determining forms of behaviour and fitting them.

We work hard to avoid making school experience a meaningless exercise in the manipulation of trivial data. In the same way, we might choose to avoid making the process of adopting technology, a transparent process which leaves the educational system unaffected. The process of adopting the technology can be active and purposeful. Technological experience need not be something had and forgotten.

Doing is doing, not construing.

Everyone is an expert on schooling; after all, they went to school for at least a decade. Yet we who work in classrooms are confronted daily by decisions to which there appear to be no ready answers, answers for which we seek endlessly in meetings with our colleagues and at conferences with peers. Why is this quest so fruitless? Is it possible that we are not very good at finding 'truths' which we can accumulate and upon which we can draw or is it that the nature of the action of teaching is not merely the sum of many answers? Why do we think that there are answers?

Peter Senge (1990) draws attention to the fashionable idea of thinking in systems and argues that one important aspect of any well-functioning organisation is that it is learning, constantly finding out more about itself but within a constantly changing framework. If we think of a classroom in which the participants are learning as a constantly changing organisation, what is the right decision one day may well be wrong the next. In order to be informed when making decisions, are we better off if we are aware of the possibilities than if we have only one predetermined course available to us? So from what can we build our body of awarenesses? We can take the advice of others but how do we know if they are telling us the right thing? We have nothing but our own experience with which to interpret the circumstances in which we find ourselves and through which to see the problems which confront us. How, other than through our own eyes, can we determine if what confronts us is the same as the circumstances described by another? How can we decide if the essential aspect of the circumstances in which we should adopt a particular strategy is present or missing? Is this a process which we can actually undertake as isolated individuals anyway? Is not every action in the classroom tempered by the situation, by those present and their understandings?

Suppose that it has become apparent that children who do not learn to type 'correctly' when they start using computers often become very fast typists with very bad 'style' and then, very difficult to convince to learn good touch-typing behaviour. Now imagine that for some reason we consider that 'correct' typing behaviour is necessary for our students. What are we going to do when we see a very miserable little girl whose family has just split up, pecking away at the keyboard writing a letter to her Granny?

Avoid the teaching of speculators
whose judgements are not confirmed by experience
(Leonardo da Vinci)

PUTTING FLESH ON THE BONES

I want to propose two strategies which might lead to recognition of others. First I want to draw attention to a strategy which can help us prepare for teaching situations and then to work on a strategy which can help us use our experience to evaluate planned actions in the situations in which the plans are operating. The first involves bringing our focus of attention to the tension which develops between what we want to achieve and how it is best achieved and the second to how we can use our experience, and that of others, to develop and evaluate strategies for use in the moment of teaching.

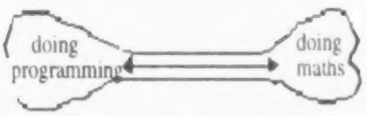
I wrote (above) about the way in which we learn to work on something which seems invasive and neutralise it until it is palatable and manageable (sometimes in the process throwing out the baby). We do not decide to destroy the thing but in the process of making it fit into our understanding of the world in which it is relevant, we sometimes do so much 'fitting' that we transform the thing in the process.

Let us look for a moment at how people use Logo6.

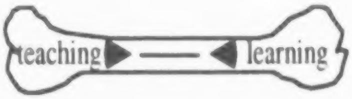
Logo can be seen as something which 'the children should experience'. If this is our goal, we might develop a small unit of Logo turtle geometry for them and 'administer' it in a computer laboratory, let's say to 8-year-olds. The process can be described as analogous to the way an organism deals with an invasive germ: the latter would be isolated and marginalised like the Logo. Alternatively, Logo could be understood as an extension of children's forms of formal expression in mathematics (see Nevile, 1991), say, in which case the focus of attention would be the subject domain and the Logo merely the expressive medium in which it is addressed. In the former case we attend to the use of the Logo and in the latter to the subject matter, so what is 'doing Logo'?

My concern just now is how do we help ourselves get access to these possibilities, not so much what they are. I suggest we try the strategy of putting 'doing Logo' on a bone[7]:

This super-simple technique helps us recognise that there might be a range of meanings available for the expression 'doing Logo' and we can start to articulate some and attach them to the bone. We are likely to discern some common aspects among examples we consider and those threads will 'flesh out' for us the tension which underlies the use of Logo in the classroom: how much attention must be given to 'doing Logo' if students are going to be able to use it as a natural form of expression in their mathematics and how much formal (remedial?) mathematics, say, are we going to have to teach if students come to think mathematics can be expressed satisfactorily in Logo? The bone starts to look more like this:



and the area in which the our attention is focussed is where there is the dynamic tension, not where there is a collection of static examples. But all parts of the bone are important to us. We need the examples to give us a sense of the possibilities and we need to have a sense of the dynamic connection between them to be able to use them. Let us now return to the earlier comments about the didactic contract and the didactic transformation. We cannot solve the teaching problem by short-circuiting the learning of the students, we cannot solve the educational development process by isolating and marginalising the challenges. But there seems to be a lot of pressure on us to make these things compatible - to bring the ends of the bones together, to find some cohesion between them:



But if learning and teaching become the same thing, we do not seem to gain: rather we find ourselves with what we despise and call 'brain-washing'. So we need ways to magnify the connections between the many aspects of teaching and learning which are of concern to us, to first come to recognise them, then to articulate them so we can manipulate them. What we need is ways of awakening our awarenesses of what is involved in what we are doing so we can make some choices about what we do.

WORKING ON EXPERIENCE

So to the second strategy. How can we awaken awarenesses if we don't know we have them or need them? For what should we be prepared, and how can we anticipate possibilities in contexts which have little meaning for us?

Let us return to the teachers who suffered the pain and from whom we might learn some lessons to save others from pain in the future.

How did those teachers learn what they learned? They tell numerous stories of incidents in their three years of project work in which they were struck by what seemed like special incidents. They describe their frustration and anguish at times as they tried to place responsibility for their pain back on those who had caused it. They tell triumphant stories of how they and their children overcame 'insurmountable hurdles' and 'made things happen'. All these stories work to form images which are suggestive, it seems, and which have been interpreted in many ways.

I want to suggest that it is only by being very careful about these stories that we can learn from them. Merely recounting a story which purports to support a generalisation is not enough.

Consider this story:

There they were, 60 children and no Logo programming expertise among the teachers yet the directive was that LogoWriter was to be *the* software for the first few months.

When we hear this, are we not tempted to jump to the generalisation that the teachers should have been taught Logo programming, at least?

Suppose we 'listen' a little more carefully to another story about this.

One child presented a program full of bugs to one of the teachers who then spent several nights trying to make sense of it. She had no idea where to start but did not want to fail the child. For several nights she struggled on, blindly, getting more and more frustrated.

Of what does such a story remind you, the reader?

It might remind you of a time when you battled with a student's problem and achieved nothing, or when you efforts were rewarded by some learning of software techniques, or it might remind you of something as far removed as when you suddenly realised how much children have in their heads which gets in the way of what they are trying to do, that novices are not empty vessels but can easily be vessels overflowing with irrelevancies.

I have asked many people to talk about the stories which are evoked from their experience when someone tells a particular story. The range is usually surprisingly wide: each listener pays attention to an aspect of the story which resonates with their experience, feelings at the time, sense of purpose for the story, and so what emerges can be based on connections which depend on similarity of physical circumstances, sense of emotion at the time, and so on. The teacher described, in working on the child's program, had many opportunities beyond the mere fixing of the program and we, as people with personal experiences which are reminded by the telling of another's story (briefly-but-vividly), can find many opportunities for working on what is available from the original story for us. We can work on the brief-but-vivid account offered by others and seek verification of the experience in our own experience.

Still we only have experiences on which to work but it is now that we start to have the material from which to develop our generalisations.

One way of thinking about this might be to think of the process thus:

We have more than one account of some aspect of experience and we can determine some threads which form common bonds between the accounts. We can start to think about abstracting from the individual accounts, forming a general, abstraction, a *generalisation*. We can do this because we can provide specific examples of when our generalisation was experienced and we can recognise other accounts of experiences as examples of the general. We can also decide when accounts of experiences are not related. We do not derive a 'definition' of the circumstances so much as a sense of what is appropriate and what is not. We become informed so that we can make analogies and recognise distinctions.

We have now started to develop a disciplined way of thinking about generalisations: have we not now got what we expect to have in every other context in which we work? Have we not now got a sense of the discipline of generalising in technology? Just as we recognise ways of legitimately developing an historical interpretation of some events, have we not now got a way of interpreting and verifying statements about technology? Or is it the case that there is no absolute way in which special cases of technological interest can be formed into general statements of technological wisdom?

I am not sure that I want to go further than to suggest that we can benefit at least as much from an awareness of the risk of generalising and assuming that the generalisations will become useful in themselves, as in collecting 'generalisations'. There is nothing in either the particular original story I told at the beginning of this paper, nor in the stories which I have heard it evoke, which leads me to the conclusion that the same result would have been inevitable if the teachers had been trained in advance, for instance. But I similarly have no evidence that this would not be the case although I have observed that 'prior training' does not necessarily work. I am not suggesting that I can identify what causes8 what but I can be informed by being alert to the seduction of 'wisdom' which I sometimes find associated with the story.

This second strategy then, is one which provides a way of evaluating personally what we are offered as generalisations, motherhood statements, by others. In the Sunrise context particularly, we have found it a useful strategy for filtering out of descriptions of experience, the useless judgments which so often get in the way of our productive use of our experience. (We reinforce this process by trying to work on accounts-of experience rather than accounts-for experience9.)

the original story

evokes

many re-minded incidents from others' experience

which when worked upon reveal different aspects of the original story to which listeners can be attending

and from the many newly-awakened awarenesses,

possibilities for the future can emerge.

CONCLUSION

My conclusion is a question: Is there a discipline which will support us without urging on us the need for making statements, asserting technological 'truths'? If we can work in a disciplined fashion and be informed by our experiences, and those of others, what strategies scaffold us and help us establish resist the pressure of undesirable practices?

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ENDNOTES

1 at the Queensland Sunrise Centre at Coombabah State Primary School.

2 offered by my colleague David Williams

3 I prefer the translation which calls this the 'didactic transformation'

4 not as opposed to a technologically-driven one, but instead of one in which 'technology' is seamlessly integrated into the existing curriculum without changing it)

5 an expression which was once stated "Don't look at me, take what is in my hand" as Islamic mysticism

6 we could equally have used word processing or something else...

7 The choice of metaphor is as much influenced by the shape of the bone as anything. The tradition of thinking this way is derived from the islamic idea that "every stick has two ends".

8 in fact, I do not even subscribe to the cause/effect view of education

9 In this, like much of our work, we are supported and informed by the work of our colleague, John Mason from the Open University in the UK.

ARE AUSTRALIAN CLASSROOMS READY FOR COMPUTERS ?

BY PAUL NEWHOUSE
Lecturer in Computer Education,
Edith Cowan University

This paper outlines the progress made in the second year of a project concerned with the implementation of computer supported learning environments for a new upper secondary mathematics course for lower ability students in Western Australia. While the number of available educational software packages is increasing at an exponential rate, the design quality is improving and the number of computers available in schools is increasing there is still very little impact of computer based applications on learning associated with classrooms. It is likely that the key reason for this discrepancy concerns the implementation strategies or models employed by teachers.

There have been three main components to the research project: classroom action research , the use of a classroom environment instrument, and a statewide survey of teachers involved in the new courses. Findings to date have highlighted the overall need for support for teachers, even very experienced and competent teachers, who want to implement computer supported learning environments. Teachers need the encouragement and support to change the classroom environment to suit the needs of their students and curriculum. Computers can both support change and cause such a change.

The teachers surveyed while demonstrating positive attitudes towards change are having a great deal of difficulty making use of computers in their classrooms. Continued in-service training, improved support materials and access to more appropriate hardware and software are required.

Last year (Newhouse, 1992) I reported on the first year of a three year research project concerned with the implementation of computer supported learning environments for a new upper secondary mathematics course for lower ability students in Western Australia, Mathematics in Practice (MiP). The course involved the use of mathematical modelling (Herrington, 1988) in the solution of real-life problem situations. Initially I worked with a local secondary teacher and his classes to determine appropriate uses of computers in the new course. We also investigated successful strategies for implementation given the limited resources and the low level of mathematics ability of the students selecting that unit of study. This paper outlines the progress made in the second year of this project.

GENERAL AIM OF THE RESEARCH

The overall aim of the study was to determine the features of particular implementation strategies or models, especially those involved in group-work support, that appeared to be associated with successful implementation. In particular which features tended to encourage positive interaction between a student and the computer and between students, and maintain positive attitudes towards the explicit curriculum. Part of this was to determine the obstacles needed to be overcome to achieve successful implementation.

The rationale for the study was that while the number of available educational software packages available is increasing at an exponential rate, the design quality is improving and the number of computers available in schools is increasing, there is still very little impact of computer based applications on learning associated with classrooms (Kissane, 1989 : Olive, 1992). It appears to be likely that the key reasons for this discrepancy concern the implementation strategies or models employed by teachers (Van Den Akker et. al., 1992).

WHERE DOES THE COMPUTER FIT IN MATHEMATICAL MODELLING ?

I contend that to realistically develop a modelling approach to mathematics learning, as opposed to a traditional didactic approach, the computer is an essential support to both the student and teacher. As Riel (1989) states, the computer is needed to allow the 'development of an appropriate functional environment'. As such I am convinced that there are many mathematical models that are not practical to investigate or implement without computer support and it is also not practical to tackle a wide range of real life problems without that support.

A computer application could support mathematical modelling in a number of ways including : to model a real environment, as an investigative tool, to generate data for model, to assist in analysis, as a computational tool, to check solutions or as a presentation/ communication tool.

IMPLEMENTATION MODELS : COMPUTERS IN CLASSROOMS

In this paper, implementation model will be taken to mean the characteristics of the method by which computer use is integrated with the implemented curriculum. It is therefore concerned with the expected roles of the computer system, support materials, teacher and students within the classroom and the manner in which it is intended these entities should interact with each other to create the intended learning environment and outcomes. I defined three main model types : Whole-class, One-to-one, and Group-work Support.

There is a question of how to define successful implementation. Obviously any definition is highly subjective. I considered an implementation model to be successful if it is perceived by the participants, teacher and students, that it contributed significantly to the delivery of the intended curriculum. For my classroom action research I translated some more formal definitions into outcome measures for the students and teacher including affective outcomes.

PROGRESS IS BEING MADE

In 1992 there were three main components to the research project. Firstly, there was continuing Classroom Action Research which involved observing and questioning two classes, one in Year 11 and one in Year 12. Secondly, I developed the use of a Classroom Environment Instrument which was tested on four classes in Year 11 and 12. Finally, I conducted a Statewide Survey of teachers involved in the Year 11 Mathematics in Practice course.

CONTINUING CLASSROOM ACTION RESEARCH

In 1992 I continued my close association with a teacher and his classes, both Year 11 and 12. However, I removed a large amount of the support I had made available to him in 1991. I largely observed the class in action working on modelling projects and gathered data by means of questionnaires and interviews.

In an analysis of the use of computers in the projects it is both difficult and pointless to try to isolate the impact of the computer use from the impact of the project/modelling approach to mathematics learning. The computer use was designed to be integrated with the modelling approach. It would therefore be counterproductive in this analysis to extract computer use factors. In a study by Riel (1989) it is asserted that it is the integration of computer use into a functional learning environment which is important not the computer use itself. Rather the following analysis will consider the whole approach to each modelling problem/ project and the extent to which the computer application supported each. This approach is supported by Olive (1992).

Although incomplete an initial analysis of the interview responses at the end of the year provided some interesting indications of the impact of the computer supported modelling approach to mathematics learning. Firstly I will consider the teacher and then the Year 12 students who had already been exposed to this approach to mathematics the previous year. Finally, I will consider the Year 11 students and compare their responses with those of the previous year's students.

THE TEACHER

The main teacher in the study would be rated as a computer literate teacher by most educators. He would also be considered to be very experienced and enthusiastic. The previous year he had expressed surprise at the amount of use of the computer which had been made throughout the year. He had also been generally pleased at the progress of the students and the running of the course.

One important perception he expressed was that he had not made as much use of computer applications in the second year as he had the previous year or would have liked to. He largely put this down to his own lack of organisation and lack of time to think about new applications. I would also add that my reduced support may also be a factor here.

He expressed the opinion that the best applications were small tasks that could be completed quickly and included a print out. He felt the most important factors in successful implementations were : being organised, having computers available, knowing the software and having experience at teaching the course. He also felt that they needed more hardware to allow increased student access and therefore allow for a greater range of applications to be used.

YEAR 12 STUDENT OUTCOMES

The mean student ranking, in terms of enjoyment and learning, of the six major projects completed during the year are given in Table 1. In general it appears that, as may be expected, enjoyment and perception of learning are reciprocally related. For example, the students enjoyed the SimCity project but didn't think they learnt anything. However, the Buying a Car project did not fit this expectation and the other project using computers, Survey of School, was ranked well in terms of learning. In answering later questions all students said that they felt that they have learned some mathematics.

In general this group of students was very satisfied with their mathematics course and was interested in using computers in the course. All students said that they liked using computers in the projects and all but two said they would have liked to have used them

TABLE 1 : Mean Student Ranking of Projects in Year 12
[n = 14] (C) implies that the project made use of a computer application

	Enjoyment		Learning	
	Mean	Order	Mean	Order
Survey of School (C)	3·9	5	3·8	3
SimCity (C)	2·4	1	4·2	6
Build a Bridge	3·4	3	4·1	5
Build a House	3·8	4	3·9	4
Sharemarket Game	4·1	6	2·4	2
Buying a Car (C)	2·6	2	1·8	1

more. From observation the students had little trouble using the Macintosh computers although six of them indicated that they had some difficulty. I believe that this was mainly in learning to use SimCity.

YEAR 11 STUDENTS COMPARED WITH PREVIOUS YEAR'S GROUP

This group of students did five of the same projects as the previous year's class and also completed two new projects (refer to Table 2). As with the Year 12 students the Buying a Car project was ranked very highly. Interestingly the other three computer supported projects were ranked low on both enjoyment and learning fairing much worse on learning than the previous year. However, it should be noted that almost all students indicated that all the projects were interesting, useful and that they learned maths from them. In addition they all liked using the computers and would like to use them more. So, this apparently lower ranking may be due to the high quality of the two new projects and improvements made to the Games and Bin Basketball projects. It may also be because the first three projects were too far in the past to remember accurately.

TABLE 2 : Mean Student Ranking of Projects in Year 11
[n = 13] (C) implies that the project made use of a computer application

	Enjoyment		Learning	
	Mean	Order*	Mean	Order*
Reticulation (C)	5·6	6 (5)	5·1	6 (2)
Subdivision of School (C)	5·6	6 (4)	4·8	5 (3)
Orienteering (C)	5·3	5 (2)	4·1	4 (1)
Bin Basketball	2·2	1 (6)	5·2	6 (5)
Games	2·8	2 (1)	3·8	3 (6)
School Function	3·2	3	3·1	2
Buying a Car (C)	3·6	4	1·8	1

Note: Numbers in parentheses indicates order given by students in 1991

OVERALL CONCLUSIONS

For all the projects most students completed projects to a standard in excess of the teacher's expectations. Most students expressed a high degree of satisfaction and enjoyment from their work. Most students also indicated that they had found the use of the computers rewarding and relevant. Most students had found little difficulty in operating the Macintosh hardware and software supplied.

Almost all of the computer applications were successfully implemented and contributed in a small but significant way to the success of the student projects. It was intended that the software support the modelling approach by providing a tool for students to use. In this sense it was successful and students opted to use the software as they saw fit.

CLASSROOM ENVIRONMENT STUDY

Fraser and Walberg (1991; x) describe an classroom environment as the 'social-psychological contexts or determinants of learning' within the classroom. It is clear that the concept of classroom environment is central to any study of the implementation of computer supported learning environments (DeCorte, 1990; 70). The important questions concern the effect of the introduction of computers into the classroom environment and whether any changes are perceived to be positive and assisting in the creation of desired attributes of the classroom environment by students and teachers.

Initially I have conducted a limited investigation of the perceived classroom environment, or beta press (Fraser and Walberg, 1991; ix), of the studied classrooms. The aims were to compare the preferred and actual environments for the studied classrooms and then to look for differences with similar classrooms where computers were not used and a classroom associated with the teacher which conducted a different course.

TABLE 3 : Classes Involved in Study

Classes Involved in Action Research				
A	Year 11	Modelling	Teacher 1	Used Computers
B	Year 12	Modelling	Teacher 1	Used Computers
Other Classes				
C	Year 12	Modelling	Teacher 2	No Computers
D	Year 12	Calculus	Teacher 1	No Computers

The instrument used I have called the CEI (Classroom Environment Instrument) which is based on the CES (Classroom Environment Scale) developed by Rudolph Moos (Fraser and Walberg, 1991; 8) The CEI has seven measures (scales) each made up of eight questions. The names of the measures are given in Table 4.

PREFERRED VERSUS ACTUAL CLASSROOM ENVIRONMENTS

There has been a lot of research conducted on the fit of preferred and actual classroom environments. Notionally it would seem that if possible the two should be closely matched to support student learning and welfare. A comparison between the two for class A revealed quite a close match. Unfortunately a preferred classroom environment was not available for class B therefore a comparison of their previous and actual environments is given.

TABLE 4 : Names of Measures for Classroom Environment Instrument
[Maximum score of 24 on each measure.]

INV	Involvement	COM	Competition
AFF	Affiliation	OO	Order and Organisation
TS	Teacher Support	TC	Teacher Control
TO	Task Orientation	INN	Innovation

It appears from the graph in Figure 1 that the classroom environment preferred by students in class A is matched closely by the perceived actual classroom environment perhaps with the except of Task Orientation (TO). The classroom was perceive to have a higher level of Task Orientation than they would have preferred. The question then is to ask whether this is primarily a function of teacher, level of maths or computer use. Unfortunately I was not able to get enough information to answer this question conclusively. However, for each of these variables I was able to keep the variable constant in comparisons involving pairs of the four classes used.

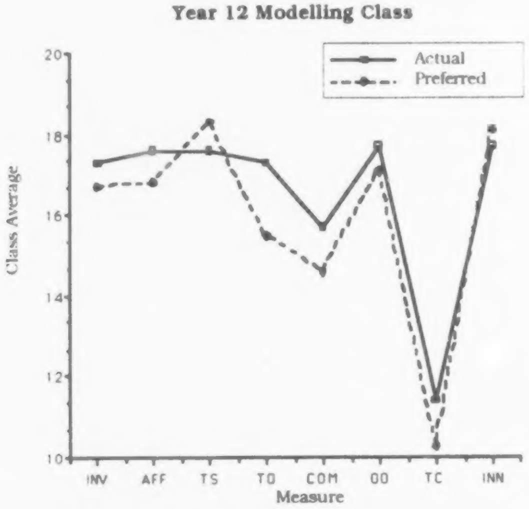

Figure 1 : Actual and Preferred Environments for Year 12 Modelling Class

COMPARISON OF CLASSROOMS ON COMPUTER USE

I compared the classroom environment measures of the two modelling classes which had different teachers, one used computers (Class B) and one did not (Class C). From the graph below (Figure 2) it appears that the perceived actual environment involving computers was lower on the measures of Competition, Teacher Control but higher on Innovation. This is consistent with a more student-centred learning environment which incorporates group work. I observed that the computer-using class did indeed complete more group-work than the other class.

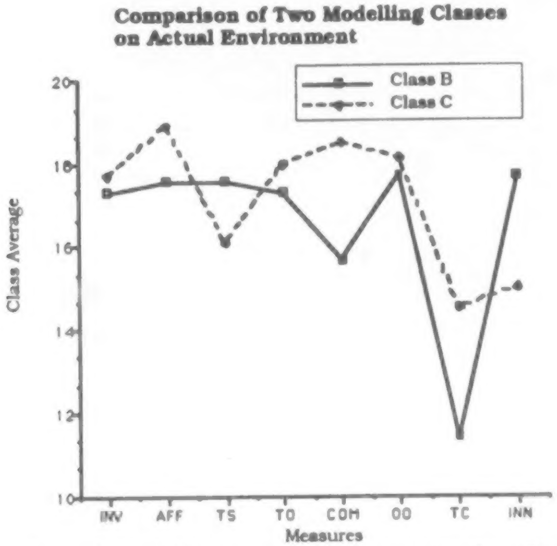

Figure 2 : Actual Environments for Year 11 Modelling Classes

A question which flows from this observation is whether the non-computer using class was 'unhappy' with these differences. That is did they prefer the classroom environment of the other group to their own. As can be seen from the graph in Figure 3 the computer-using class actually preferred a lower level of Competition, Teacher Control and a higher level of Innovation than the other class. Further, the perceived preferred and actual environments (Graph not shown) for the non-computer using class matched very closely. It would appear that for both classes the preferred and actual environments matched.

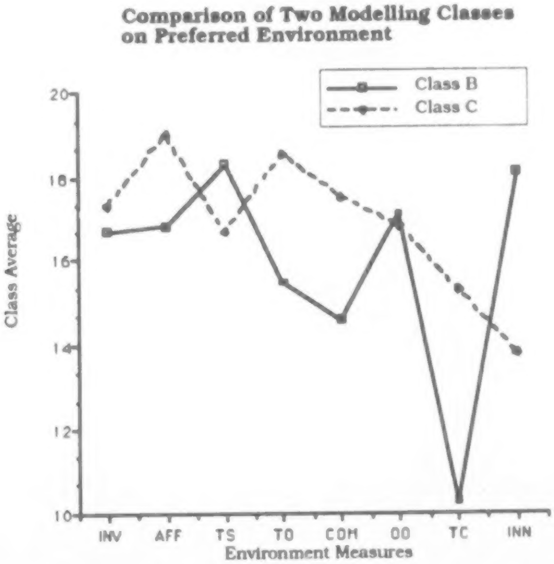

Figure 3 : Preferred Environments for Two Year 11 Modelling Classes

Does this mean that the teacher and students arrange the actual classroom to suit what the students want or does this mean that students adapt their wishes to suit what they have become accustomed to ? To consider this question I will look at a comparison of two classes which had the main teacher.

COMPARISON OF CLASSES WITH SAME TEACHER BUT DIFFERENT CONTENT

Which comes first, the preferred or the actual environments? It may be argued that two classes with the same teacher and similarly aged students are likely to have similar actual environments. If the preferred environments are similar and the teacher and students arrange the actual classroom to suit what is preferred then the actual environments should be similar. It would seem that the preferred classroom comes first. If not, then it would seem that the teacher sets up an environment and the students may then modify their preferred environment to suit this.

The two classes compared were Class B, the main class studied, and Class D which was not using computers and the students were studying another mathematics course, Calculus. From the graph in Figure 4 it would appear that this second class has a similar preferred environment on most measures. Perhaps these students prefer a higher level of Competition, Task Orientation and Involvement than our main class. The question is whether the teacher and students in Class D provided an environment to suit this ?

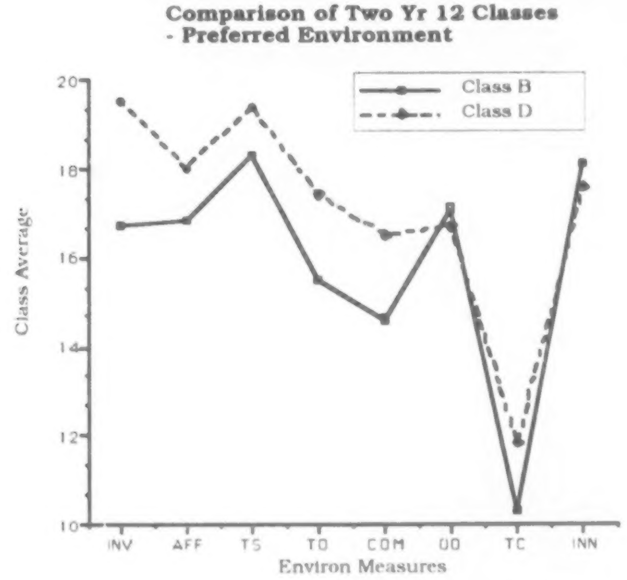

Figure 4 : Preferred Environments for Year 12 Classes

From the graph in Figure 5 comparing the preferred and actual environments of Class D it appears that there is a poor match. I believe that this is in part explained by the difference in the approach of the teacher to that class, part of which is the non-use of computers. He had a much more 'conservative' teacher-centred approach to the class and thus it is not surprising that this classroom is not high enough on Involvement, Affiliation, Teacher Support, Order and Organisation and Innovation for these students. So it would seem that the teacher is the key to setting up the classroom environment and in the case of Class C, the other Modelling class, it is likely that the students modified their environment preferences to more closely match those offered by the other teacher.

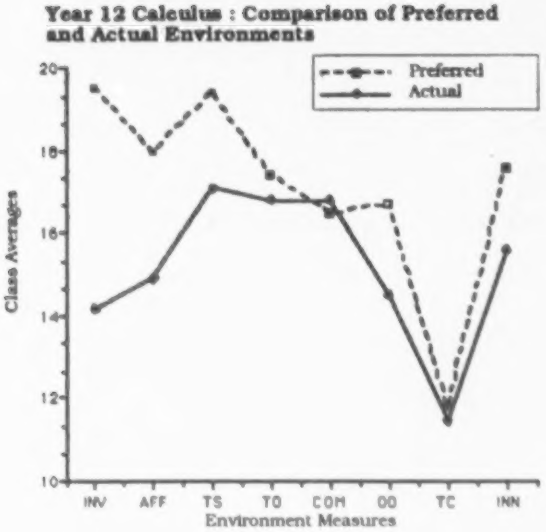

Figure 5 : Actual and Preferred Environments for Year 12 Calculus Class

The question which could be asked is whether this is just due to differences in the type of student choosing to do each of the courses. We have already seen that while there is not a lot of difference in the preferred classrooms of the two groups, the higher ability group tends to want greater Involvement. Looking at the graph in Figure 5 there seems to be clear differences in what the students want and how they perceive the classroom to be on a number of the measures. I can only conclude that most of these differences are due to the teacher's approach to the two classes, part of which would be the teacher's attitude towards the subjects and part of which is likely to be the teacher's interest in using computer supported group-work projects in the Modelling class. Consistent with the literature it would seem that the classroom environment is heavily dependent on the teacher (Van Den Akker et. al., 1992; 68 : Olive, 1992; 503). What is interesting is that the teacher is able to change the environment. In this case the catalyst for the change was the new approach to learning mathematics facilitated by computer applications.

What I would like to suggest thus far from this section of the study is that the teacher is central to the creation of the classroom environment. Teachers can create a varying number of types of environments. In order to better match the preferred environment of their students teachers need to be given a degree of freedom and supporting resources. In this case the new courses permitted the freedom and along with the use of computers provided some of the resources to allow the teacher to set up such an appropriate environment. In the words of Olive (1992; 503) the teacher was able to 'take charge of technology and use it to transform his own teaching environment'.

STATE-WIDE QUESTIONNAIRE

During the year a questionnaire was sent to all schools in the state addressed to all teachers of the MiP course. The questions were designed to collect data on the attitudes towards the course, classes and teaching mathematics, the approach to teaching these classes, the type of instruction and learning activities used, the amount and type of computer support used with these classes, obstacles to computer use with these classes, and details about the type of computer hardware and software used. There were 193 teachers who returned the survey of which 191 were useable. These teachers represented 107 schools in the state.

INITIAL FINDINGS

The first intention of the survey was to try to identify classroom organisation and attitude characteristics of teachers of the Maths in Practice unit and the degree to which they use computers and what they do with them. The second intention was to determine whether there was any connection between the teacher characteristics and computer use in the unit.

Generally it could be said that the teachers did not dislike teaching the unit and were more likely to see the unit as valuable than not. Almost all the teachers enjoyed teaching mathematics in general. They tended not to be pleased with the standard of work produced by students. Of interest is that most of the teachers encouraged students to help each other and preferred students to take responsibility for their own learning. Classroom activities organised by these teachers for MiP tended to be mainly projects, often conducted as group-work exercises.

Of the 191 teachers, 80 (43%) made use of computers at times in their MiP classes. Table 5 shows the responses to the possible reasons for not using computers. The two most frequent responses are, I believe, very significant. In particular that 59% of these teachers are looking for a computer laboratory implementation and nearly half of them are not confident in using computers. Therefore a large obstacle is the lack of computer literacy and experience of teachers involved in the units. This would come as no surprise and yet this is despite quite a large amount of in-service work conducted over the past two years. The continuing perception that you need a laboratory to use computers to assist in learning is worrying.

TABLE 5 : Why MiP Teachers Don't Use Computers

"Indicate why you do not use a computer in the MiP class by ticking as many of the following as are relevant."

Reason for Not Using Computers	% of non-computer users
It is difficult to get access to a computer laboratory.	59
I am not confident in using a computer	46
It is difficult to get access to one computer.	40
There is no useful software available	28
My students do not know how to use computers	24
Using a computer takes too much time and effort.	19
The computer is not relevant to what the students do	12
The computer is not suitable for me to use.	4
The computer is not suitable for the students to use.	3

It is interesting to compare these with the findings of a U.S. study reported by Olive (1992; 511) which identified 'four forces that inhibit effective uses of technology by teachers'. Two are those found in my survey ; lack of access to hardware and software, and lack of training and experience in using technology as a learning tool on the part of teachers. The two which are missing from my list are : lack of support from school and system for diverging from the mandated curriculum, and accountability only in terms of student performance on standardized tests. This is not surprising since the two modelling courses have no external examinations and the education system has supported the notion of a flexible curriculum for the courses.

What of the teachers who did use computers in their classrooms? The typical teacher tended only to use it sometimes, rarely for demonstration. They considered themselves to be computer literate and rarely gave students a choice in using computers. It appears that teachers locate suitable software to go with a certain project and then get each student to use the software on that project.

Do teachers have enough access to hardware? When considering the number of computers available and used by teachers with MiP classes I determined four ranges of values to correspond with the best possible computer access strategies assuming a class size of between 20 and 25.

TABLE 6 : Computers Used

The number of computers usually used with the class. [n=80]

No. of Computers	%	Potential Computer Access Strategies
0 - 4	39	Rostered groups or individuals
5 - 9	24	Unlimited groups or rostered individuals
10 - 19	33	Unlimited pairs or rostered individuals
20 - 28	4	Unlimited individuals

What types or brands of computers do these teachers use with their classes ? The table below shows the high proportion of IBM and compatibles used in this state in secondary schools. It is likely that most of these would only be running under MS-DOS, although I did not specifically ask for this information. Associated with this is that only 55 of the 80 teachers (69%) have mice available as an input device.

TABLE 7 : Operating Type Used

Type of computer as a percentage of teachers who do use computers with their classes. [n = 80]

Type/Brand	%	Type/Brand	%
IBM or compatible	76	Commodore Amiga	3
Macintosh	24	Other	1
BBC Archimedes	16		

The type of operating system available appears to be a major problem for implementing a range of computer applications in this unit. While a lot of CAL packages are available to run under MS-DOS there are many that do not and further, a number of useful tools are not easy to use in the MS-DOS environment. It is therefore not surprising that in Table 8 by far the most used pieces of software are spreadsheets and word processors. It seems to me that with the relative lack of use of simulations, statistics packages, databases, graphics and graphing packages the operating system available to most may be causing a problem. It is however gratifying to see Drill and Practice software at the bottom of the list. This ties in with the U.S. report (Olive, 1992; 511) that 70% of teachers do not like drill-and-practice software. This would suggest that these teachers are at the point where they are ready to move from the traditional static role of teachers to a more dynamic one which may reform the curriculum and transform their classrooms (Olive, 1992; 510).

TABLE 8 : Type of Software Used

Percentage of teachers who do use computers with their classes. [n = 80]

Software Type	%	Software Type	%
Spreadsheet	95	Simulation	25
Word Processor	56	Demonstration	18
Graphing	34	Statistics Package	15
Graphics	31	Drill and Practice	4
Database	29		

Initially the picture the survey data appears to be painting is one of a group of teachers working to implement the new course as intended and wanting to make use of computer applications. However, they are finding it difficult to give their students adequate access to computers some of which is as a result of a lack of knowledge and expertise in implementation. Over 60% of the teachers who do use computers are in a situation where the only means of providing access is by a roster system and/or group work. This in fact fits the classroom learning model many of them stated that they want to pursue. Finally, most teachers appear to be limited in the type of software they use either due to the use of MS-DOS or their own lack of knowledge and experience.

CONCLUSIONS AND FUTURE DIRECTIONS

The study is critically interested in the impact of computers in the classroom, particularly mathematics classrooms involved in mathematical modelling. As such the second year of the study has continued to closely examine a group of students and a teacher making use of limited access to computer applications. To add to this it has investigated the classroom environment associated with that class and has begun the process of widening the scope to consider a range of similar classes throughout the state.

The continuing classroom action research has highlighted the need for support for teachers, even very experienced and competent teachers. Van Den Akker et. al. (1992) found that the interaction between teacher and courseware and the design of support materials were crucial to the successful implementation of computer supported learning. The main teacher used in this study found it difficult to find and use additional courseware with the reduced support available to him. For the same reason he lacked sufficient support materials and therefore not surprisingly used computers less than in the previous year.

In the study by Riel (1989) it was found that while classroom organisation was not changed by computer use the patterns of interaction between students and students and teacher were changed. My initial investigation of the classroom environment of the main class would seem to indicate that teachers may in fact alter the classroom organisation and that computer use may be part of the motivation and/or support to do so. It certainly would appear that patterns of interaction change. This however needs a far wider study to be more confident about.

The statewide survey has shown that teachers in these courses are having difficulty making use of computers in their classrooms. However, they seem to have a positive attitude towards the courses, the change in teaching/learning strategies and the use of computers within the course. It seems that more in-service training is required, improved support materials and access to more appropriate (GUI operating systems) hardware and software in order to increase the use of computers to support these courses.

In 1993 the research project will be extended to consider in more depth a sample of teachers taken from those involved in the survey. The study will continue to concentrate more on classroom organisation and interaction patterns in the classroom. This study will seek to add to the findings of Riel and others (e.g. Van Den Akker et. al., 1992) and contribute to the ongoing debate concerning the relationship between computer use and the classroom environment or culture (e.g. Olson, 1988).

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THE INFLUENCE OF TRAINING ON BEGINNING TEACHERS' USE OF COMPUTERS.

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This study investigated the level of computer use among beginning teachers. Beginning teachers were asked to complete a questionnaire towards the end of their first year of teaching. The responses provided information concerning the computing courses completed by the teachers during their teacher training, the place of computers in their schools, the amount of use the teachers were making with computers and their perceptions of the computer education needs of the beginning teacher.

Analysis of this data revealed despite computing having a high profile in the majority of schools, there were widely varying levels of computer use among the beginning teachers. Differences were observed in patterns of usage between primary and secondary teachers and these patterns appeared to reflect the nature of the computing courses received during training.

INTRODUCTION

Computers now have an established place in school education systems. There is an expectation among all stakeholders in the education process that school students will receive broad experience the new technologies. The expectations of the stakeholders are often quite high. They are aware of the potential advantages to be derived from instructional applications of computer technology and expect that students will receive some of these advantages at some stage in their schooling. From school based experiences, it is anticipated that students will develop the necessary levels of knowledge and skills in Information Technology (IT) to enable them to take advantage of the opportunities afforded by computers beyond school settings.

THE NEED FOR COMPUTER EDUCATION

The use of computers as a tool for the learner extends through all educational levels. Although many would expect to find sound levels of Information Technology (IT) skills among students who enter universities to complete teacher training, in practice this is often not the case. Recent investigations carried out among tertiary entrants in teaching courses have found the computing skills of many students to be sadly lacking (Summers, 1990 & Wilson, 1990), Large numbers of students still leave secondary education with only minimal skills and experience with computer technology. In occupations such as teaching, where the use of computers plays a significant role in the quality of the services provided, there is a clear need for programmes of study to ensure that graduates have achieved the appropriate levels of IT skill and expertise.

Bigum (1990) rationalises the need for computer education in teacher training programmes through issues of economy as well as pedagogy. He argues quite rightfully that there needs to be more deliberation by teachers in the selection and application of computing resources in instructional settings. Frequently rhetoric and good intentions are used as guides for good practice more often than knowledge and informed practice.

Since computers and computing are interdisciplinary in nature, some will argue that the appropriate skills and knowledge can be derived from meaningful application of the technology rather than instruction in applied settings. Although this represents the ideal scenario, frequently it is not achievable in traditional courses of study.

COMPUTER EDUCATION PROGRAMMES

As with school based IT programmes, the choices facing teacher educators in the design and implementation of appropriate courses for teacher educators are many and varied. Owen (1992) provides a useful summary of training programmes by considering those aspects of the field that most influence the nature of the given instruction. He describes models of in-service training, all of which have relevance and possibility in pre-service training programmes. The models are distinguished by the parameter on which they centre.

- hardware centred, the machine is the focus of the instruction and content is based on knowing the machine and how it works.
- software centred, an item or application is taught. The aim of the instruction being to develop competence and expertise in the program itself.
- curriculum centred, computing is taught in the context of a particular curriculum.
- classroom centred, the instruction includes investigations into classroom practices and learning outcomes,
- whole school centred, the instruction brings the whole school to account for values about key issues, resource management and curriculum applications.
- teacher centred, instruction considers individual teachers roles and aspirations and maps programmes that are in accord with personal development needs of each.

Although the demands and requirements for in-service training differ considerably from those associated with pre-service training, within the field of computer education, there are many similar inputs and planned outcomes. An important consideration in the planning of information technology programmes in teacher education is deriving effective use from those factors that will aid in the construction of the beginning teachers' conceptual models of computers and computing as tools within all aspects of the profession. Although difficult to implement in pre-service training, conventional teacher education IT programmes are often a blend of the models described by Owen (1992).

Rhodes (1989) uses the terms, Deficit and Skills to describe dichotomous models of IT training for teachers. In courses based on the Deficit Model, emphasis within the programme is towards developing confidence in the use of hardware and software. In such programmers technology is central to the instruction while educational issues assume a secondary role. In the Skills Model, the teacher rather than the technology is central to the course and the emphasis is placed upon encouraging teachers to use the technology within the classroom. Wild (1991) considers that the differentiation of teaching models based on methodology alone leads to an oversimplification of the dichotomy that exists between such models. He argues for a return to the issue of needs identification to gain more insight into inherent differences in the nature of teacher training courses.

There are several identifiable forms of contemporary computing course given to teacher- training students in Australian universities. In some instances, courses of a formal nature are delivered to ensure appropriate knowledge and skills are developed by all students. These courses are very much in the style of the Deficit Model (Rhodes, 1989). The capacity of a formal course of instruction to fully develop IT skills and knowledge is frequently questioned in the school context (Oliver, in press). One would suspect that similar shortcomings may be evident in preservice teacher training. On the other hand, such courses are often the only possible way that minimal skills can be guaranteed outcomes of programmes and courses. Bigum (1990) describes an approach to teacher training that he called "situated learning". Such an approach provides the necessary skills and expertise through their development and application in meaningful contexts. This approach is along the continuum to the Skills Model (Rhodes, 1989).

It is difficult to judge the best form of IT programme that can be delivered in any one setting. The effectiveness of the training programmes must reflect the needs of the beginning teacher. Evaluation of training programmes is frequently undertaken in terms of knowledge of course content and the development of personal skills. A more valid test of success is achieved by examining transferable skills and these are made evident only when the graduates apply their skills to actual teaching. Computer literacy by its very definition must transcend the content of an instructional programme to encompass such outcomes as the attitudes that are developed, students self-sufficiency and the transferability of the knowledge and skills to new situations. This paper describes a study that sought to investigate the effectiveness of different forms IT training within a teacher training programme by examining the actions of beginning teachers in applying information technologies in their initial teaching positions.

There are many factors that can influence the use of computers among beginning teachers. Of paramount importance would appear to be the nature and level of computer experience and training, including the level of practice of computer use in curriculum settings. There are of course many other factors such as those that have been found to impede experienced teachers from applying computer technology. Bersan & Oliver (1991) listed some of these as inadequate access to hardware and software, insufficient skills in applying computers in their teaching as well as the demands and rigours of teaching. The purpose of the present study was to determine the level of uptake of computers exhibited by beginning teachers from a university in Western Australia and to investigate factors associated with computer training that might influence this uptake. The following research questions were framed to achieve these goals.

- Does the level of computer education received during training influence the level of computer uptake of beginning teachers?
- Does the form of computer education received during training influence the level of computer uptake of beginning teachers?

METHODOLOGY

The subjects of the study were graduating teachers from a Western Australian university in their first year of teaching. Data was gathered from this sample of teachers through a questionnaire. The questionnaire contained items that sought the following information from each teacher:

- the training course undertaken,
- the level of teaching, primary secondary or early childhood,
- the organisation of computing resources within the school,
- the availability and quality of the computing resources,
- personal usage patterns of the computing resources and
- teachers' judgments of the quality of their computer education.

From a total graduation of three hundred and sixty five teachers, one hundred and eighty six were given immediate teaching postings. The questionnaire was sent to these teachers and initially seventy responses were gained. From information received, fifteen of the graduating teachers were found to have left their positions. A follow up mailing resulted in the return of another forty seven responses and this gave a total return of one hundred and twenty two returns from one hundred and seventy one beginning teachers. The sample from which the results are drawn, represented seventy one percent of the population, an acceptable figure by most standards.

The questionnaires necessarily required teachers to identify themselves so that follow-up letters could be sent to encourage the participation of the largest number of beginning teachers. It is likely that some teachers chose not to participate due to the fact of possible identification. Furthermore one could presume that predominant among the non-participating teachers would be those who were not using computer technology and did not wish to be identified as such. This would suggest that the information presented in the study might not truly reflect the norm and that the figures for computer uptake might be less than initially evident from the obtained responses. This fact should be borne in mind as the results obtained from the questionnaires are considered.

RESULTS

THE SAMPLE

At this university the teaching programme offers differing courses for teachers in the three areas. In the primary and early childhood areas, students study a compulsory computer education course in their first year of training while in the secondary programme, there is no compulsory course. In all areas, students can elect to complete an elective unit in computer education. There is also in the secondary programme, a course of study for beginning computing teachers who seek to become teachers of computing studies and these students undertake a large number of computer related subjects. A breakdown of the computer education training received by the beginning teachers involved in this study is given in Table 1.

Table 1
Computing Courses Studied During Teacher Training

Course	%
Compulsory Computing Unit	41
Computing Elective Unit	22
Computer Studies Teaching Units	5
No Formal Unit	32

The instructional programmes completed by the beginning teachers differed considerably in objectives and content. A better understanding of the skills and expertise of the graduating teachers can be gained by considering each of these courses separately.

1. COMPULSORY COMPUTING UNIT.

This unit was studied by all primary teaching students. It was delivered in the first year of their training programme and was primarily a hands-on unit. The unit ran for three hours per week over a 13 week semester and was delivered in a computing laboratory with a network computers. The model of computer used in the course is used widely in primary schools throughout Western Australia. Few primary schools in this state do not contain numbers of these machines for classroom use.

The content of this unit was very heavily tied to the Western Australian primary school curriculum. Students learned to use the computer in a novel approach that had them mimic the actions of primary students in practical classroom settings. For example, the word processor was used as means to record classroom activities. The students learned to use a variety of software packages designed for classroom use. They learned implementation strategies and completed assignments that involved the use of computers in an integrated fashion across broad sections of the primary school curriculum. At all times the emphasis and direction of the instruction and activity was towards the development of skills and understanding in classroom applications of computers as an aid to the teaching learning programme.

2. COMPUTING ELECTIVE

The computing elective undertaken by many of the secondary teachers was distinctly different in aims and content to the primary graduates. This course had a productivity orientation and run in the students third and final year of training. Students learned the components of the integrated package. The class sessions revolved around instruction in learning to use the word processor, spreadsheet, database and communications facilities. Students received instruction in classroom applications of computers in a lecture situation. Lectures on modes of implementation, potential uses of computers and research findings were given during the course.

Assessment in the course involved the submission of assignments. Each of the assignments tested the students' abilities to use the software package and was created in a setting that prompted thought and activity in educational applications of the technology. For example, the spreadsheet assignment involved the establishment of a marks book, the word processing assignment involved research into computer applications while the database assignment required students to plan lessons in their major teaching area where students would use the computer as a tool in the teaching/learning process.

This course was designed and delivered in a manner that primarily sought to make the teaching students competent and confident users of computers in personal settings. The curriculum applications were included in the course to facilitate the transfer of computer usage to classroom settings. The students were not exposed to particular software packages for their major subject area. The programme was designed around the assumption that given personal computing skills, the teachers would have the skills and expertise to make classroom use in their subject settings.

3. COMPUTER STUDIES TEACHING UNITS

The small number of students who completed these units received a solid background in computers from a technically oriented programme. Their course consisted of three units in computer science including studies in programming, hardware and systems analysis. The students completed two curriculum units, the focus of which was computing courses in the secondary schools and the development of appropriate teaching strategies.

The students came away from these courses with a high degree of understanding and skills in the use and application of computers. Their skills did not necessarily extend to classroom applications of computers in instructional settings.

4. NO FORMAL UNIT

The secondary teaching students who chose not to complete the computing elective received very little exposure to computers in their university course. Computers are not used widely as instructional aids by the lecturing staff. Although the majority of curriculum courses given to the students, involved mention and demonstration of classroom computer use, there was very little practical experience available to students in such courses.

Many of the students who chose not to study the elective had some degree of computer experience. Small numbers of students had studied computing in their secondary schooling. Approximately fifty percent of the students in the Faculty of Education at this university use personal computers in the preparation of assignments. The university has large amounts of computing resources for use in the academic programme and students regularly make use of these facilities for personal needs.

It can be judged then, that a considerable proportion of the beginning teachers who received no formal computer education in their training were still able to graduate with reasonable levels of computer literacy. Their knowledge and skills would probably be closely aligned to the students who studied the computing elective, consisting in the main of personal productivity skills.

AVAILABILITY OF RESOURCES

The purpose of this study was to compare the usage made of computers by the beginning teachers and to investigate whether patterns of usage could be linked to the level and form of computer education received. Because this necessarily involved a comparison of usage across primary and secondary schools, it was necessary to establish other factors that may have influenced computer uptake. High among these factors must be the level of access to computers.

To aid in the comparison, it was necessary to judge whether there was a difference in the level of resourcing in the primary and secondary school settings. The questionnaire asked teachers to judge the both the availability of the hardware and the quality of the software in their schools. The beginning teachers' ratings of the availability of hardware (Table 2) were generally positive.

The responses of the primary and secondary teachers concerning hardware availability and software quality were recoded to enable a comparison to be drawn. The responses of those teachers who could not judge the quality and availability of their hardware and software were removed. Analysis of variance indicated no significant difference in the perceptions of the beginning teachers concerning

Table 2
Beginning Teachers' Ratings of Computing Resources for Classroom Use

	very low	low	unsure	high	very high
Hardware Availability (%)					
Primary	2	19	8	39	31
Secondary	4	24	18	39	15
Software Quality (%)					
Primary	4	25	23	37	10
Secondary	4	16	31	34	13

the availability of computers for classroom use (F(1,97) = 1.64, ns) nor was there any difference in judgements concerning the quality of the available software (F(1,81) = 0.49, ns).

PATTERNS OF USAGE

The beginning teachers were asked to judge the number of hours in a week that made of computers in three areas:

- *administrative use*, as a marks book, for record keeping, reporting etc.
- *teaching use*, as an instructional aid in the classroom and,
- *personal productivity*, to create teaching materials, for lesson planning, lesson programming etc.

Table 3 shows the level of usage made by the beginning primary teachers in each of these areas. While there appears to be considerable use made of computers for teaching purposes, the usage made for administration and personal productivity is much lower. In order to gain some insight into what might be considered normal practice in primary schools, the beginning teachers were asked to judge the levels of computer usage made in each of the categories by other members of staff (Table 4). A number of the responses indicated that people had difficulty quantifying usage patterns among other staff members in a general sense, so the figures mentioned must be seen as a guide only.

The responses of the primary teachers indicated that they judged themselves to make substantially less use of computers in their teaching than other teachers in their schools. In a similar manner to their own use, the beginning teachers judged that their peers made most use of computers as teaching aids and used computers for administration and personal productivity to a lesser degree. It is difficult to speculate as to the reasons for these unexpected outcome. Given the currency of their training and their familiarity with the new technologies, one could have expected the level of computer usage of the beginning teachers to have matched or even exceeded that of their peers.

Table 3
Beginning Primary Teachers' Judgement of Their Weekly Level of Computing Usage

	0 hrs	0-1 hrs	1-2 hrs	2-3 hrs	> 3 hrs
Administration %	84	8	4	2	2
Teaching %	30	35	25	6	4
Personal %	73	21	4	2	0

Table 4.
Beginning Primary Teachers Judgement of The Average Weekly Level of Computing Usage Among Other Teachers

	0 hrs	0-1 hrs	1-2 hrs	2-3 hrs	> 3 hrs
Administration %	33	15	17	15	19
Teaching %	9	33	27	11	20
Personal %	36	32	14	11	7

Table 5
Beginning Secondary Teachers' Judgement of Their Weekly Level of Computing Usage

	0 hrs	0-1 hrs	1-2 hrs	2-3 hrs	> 3 hrs
Administration %	48	33	9	4	6
Teaching %	63	19	7	5	6
Personal %	40	25	16	10	9

On the other hand, beginning teachers face considerable pressures in their early days to gain their feet in the classroom. Unnecessary challenging tasks such as implementing computer programmes often receive a lower priority than more demanding tasks such as classroom management and lesson programming. Table 5 shows the judged levels of computer usage of the secondary teachers. It is evident from these figures that the perceived major use was personal productivity and the least level of computer usage was judged to be for teaching purposes. The secondary beginning teachers also judged their levels of usage to be somewhat lower than their more experienced colleagues (Table 6). The experienced teachers were judged to make considerable use of computers for productivity and teaching purposes. A useful comparison between the figures is to compare the numbers of teachers from both groups judged not to use computers at all in each of the three areas. The numbers of beginning teachers in these categories greatly exceed the numbers of experienced teachers.

Table 6
Beginning Secondary Teachers' Judgement of Average Weekly Level of Computing Usage Among Other Teachers

	0 hrs	0-1 hrs	1-2 hrs	2-3 hrs	> 3 hrs
Administration %	17	24	17	7	35
Teaching %	26	24	19	9	22
Personal %	14	28	33	7	18

LEVEL OF TRAINING VS COMPUTER USAGE

The first research question to be answered was whether the he level of usage of computers made by beginning teachers would be influenced by the level of computer education received during training. The secondary graduates provided a sample with which to seek an answer to this question. Approximately half of the group had undertaken formal computer education studies during their teacher training while the remainder had undertaken none. The number of hours of usage for each teacher within each of these groups was calculated and compared to determine whether differences existed in their levels of usage (Table 7).

The total usage figure for both groups was exactly the same. While small variations existed in specific usage figures among the two groups, analysis of variance found none of these to be significantly different. This finding was quite unexpected and suggested that there are stronger factors in play, that determine the level of usage that beginning teachers make of computers. It is interesting to note that within the computer education component of the secondary teacher programme undertaken by these teachers, the course emphasised the development of personal skills in computer use. The course provided the students with skills in applications of computers that are best suited to administration and personal productivity. Support for a course of this nature is derived from the argument that once students have strong personal computing skills they will then be able to apply these skills to using the computer in their teaching. This argument does not appear to be supported by these findings.

Table 7.
Hours per Week of Computer Usage Made by Beginning Secondary Teachers With and Without Formal Training in Computer Education

	Teaching	Administration	Personal	Total
With Formal Training	0.89	0.84	1.07	2.80
Without Formal Training	0.50	0.97	1.33	2.80

Interpreting these findings is difficult and can only be speculative. It could be that the nature of the formal course taken by the students simply served to develop skills and knowledge that were easily gained by other students by personal and practical use in other settings. It could be that those students who chose not to take the formal course had well developed knowledge and skills to start with. Although this was not measured, it was not likely to be the case. There were only limited opportunities and experiences in computing available to students in their courses and these would apply to all students. It would appear though, that the delivery of a formal course with an emphasis on applications needs reassessing if the aim is to produce students who will use computers in classroom applications.

Table 8.
Mean Hours per Week of Computer Usage Made by Primary and Secondary Beginning Teachers

	Teaching	Administration	Personal	Total
Secondary	1.72	1.90**	2.22***	2.86*
Primary	2.19*	1.28	1.36	1.83

$^{*}p < 0.05$ $^{**}p < 0.01$ $^{***}p < 0.001$

FORM OF TRAINING VS COMPUTER USAGE

Within the primary teacher education programme, the computer education course focused on curriculum applications of the computer while the computer education programme within the secondary programme focused on personal computer use. The number of hours usage for teachers from these groups were calculated and are shown in Table 8. Analysis of variance of the number of hours of use of computers between these groups of graduates was performed to see whether significant differences existed in their levels of uptake.Table 8 shows that the secondary graduates made significantly more total use of the computer than their primary counterparts ($F(1,114) = 4.76, p< 0.05$). This difference was brought about by significantly higher levels of administrative usage ($F(1,114) = 10.097, p< 0.01$) and personal computer use ($F(1,114) = 15.373, p< 0.001$). The primary graduates on the other hand used the computer significantly more in their classroom teaching ($F(1,114) = 4.79, p<0.05$). These findings support the contention that the form of computer education and computer training received during teacher training, influences the level and nature of computer uptake of beginning teachers.

Table 9. Mean Hours per Week of Computer Usage Made by Primary and Secondary Experienced Teachers

	Teaching	Administration	Personal	Total
Secondary	1.78	2.17	1.86*	5.81
Primary	2.00	1.73	1.20	4.93

* $p < 0.05$

There are often quite distinct differences in teacher behaviour between primary and secondary schooling and this should be expected in computer usage. This study used measures of experienced teachers' practices in this regard as a means to compare practices between the two areas of schooling. Table 9 shows these differences in usage as judged by the beginning teachers.

Differences between the primary and secondary experienced teachers are not so evident. Analysis of variance was used to test the differences and it was only in the level of personal productivity that a significant difference was found to exist. The level of usage among the secondary teachers was not different to that of the primary teachers ($F(1, 98) = 0.22$, ns). These figures suggest that after a period of time, in relation to computer usage, differences in teaching conditions at primary and secondary schools will lessen for the beginning teachers. Initially, however, it may be that variations in conditions, availability of resources, teaching demands, all local and immediate factors, are pervading and are more significant in the short term than the beginning teachers' training and education.

SUMMARY

The findings in this paper must be viewed within the light of the limitations in the methodology and data gathering in the study. In the first instance, the hours of usage that are used to make the findings are judged rather than actual. The process of estimating and judging computer usage has its drawbacks. People tend to overestimate rather than underestimate in such instances. This not totally limiting because when such a pattern occurs across a sample. Although the gained measures might be larger than actual measures, the differences in which we are interested should still be the same. It can also be argued that the practices of a beginning teacher may not provide a truly accurate picture of the underlying knowledge and understanding of that person. The constraints and difficulties associated with beginning teaching may not be the ideal environment to display actual beliefs and training outcomes. A study after three or four years of service may be a more valid test of outcomes.

Another limitation of the study is its failure to control for the many variables that can and will, influence computer uptake. There are often quite distinct differences in teacher behaviour between primary and secondary schooling and this should be expected in computer usage. This study used measures of experienced teachers' practices in this regard as a means to compare practices between the two areas of schooling. These figures demonstrated differences between the experienced teachers that were not consistent among the beginning teachers. It is to be expected that other factors apart from those considered, will influence beginning teachers' levels of computer usage.

Despite these limitations, there appear to be some interesting outcomes for teacher educators. In the first instance, the form of computer education appeared to be a significant factor in influencing the computer practices of beginning teachers. When the nature of computer usage was compared between primary and secondary beginning teachers, the usage patterns mirrored the nature of the instructional programmes. While primary students received instruction emphasising curriculum applications and classroom implementations, the secondary students who completed a computer education course, learned use of the computer as a personal tool. In their teaching, the primary graduates made significantly more use of the computer as an instructional aid while the secondary beginning teachers made significantly more use of the computer for administration and personal productivity. These practices were reported by the beginning teachers despite their perceptions of differing practices being made by others in their schools.

On the question of whether the amount of instruction in computer education might influence practice, the study did not find this to be so. Comparisons of computer use between students who completed a formal course and others who did not found no significant difference in any of the areas of computer usage. This finding must be interpreted in light of the nature of the formal training received. The students were given instruction in the use of the computer as a personal tool. It was found that skills and knowledge in this area can be gained from other sources. The expectation that students would be able to apply these skills to classroom applications was not evident.

This study has demonstrated the need for teacher educators to be critical of their IT programmes and to use more than conventional means to assess their outcomes and success. The study found that despite well organised and well delivered instructional programmes, students' transfer of the learning to classroom applications was limited. Further studies to investigate the effectiveness of differing instructional programmes such as that described by Bigum (1990), would appear to be valuable in guiding teacher educators in the planning and delivery of effective IT programmes for pre-service teachers.

Although this study appears to have established differences in computer use, and probable causes have been suggested, it has not been able to strongly defend the reasons for these differences. Heywood and Norman (1988) report on a study in which they sought to establish reasons why teachers avoided the use of computers. Heywood and Norman used attribution theory to expose and analyse causal structures. They sought to determine patterns in responses and to identify the reactions of different categories of users. There is a planned follow-up to this study that will seek to use similar methodologies to further investigate influencing factors in computer use. If there are differing outcomes from varying instructional programmes, the identification of these discrete differences could provide valuable guidance to curriculum planners and writers.

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INFORMATION RETRIEVAL FROM INTERACTIVE MULTIMEDIA SOURCES

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This paper reports a project that is investigating the use of interactive multimedia as an information source in classroom research activities. Two phases of the project to date, have involved upper primary school students using the Mammals Multimedia Encyclopaedia (1990) as a source of information in independent research projects. Both phases have found that students find the program easy to use and have little trouble navigating through the levels to find information.

Despite having focus questions to aid their inquiry, students have been observed to concentrate their information seeking on items of a textual nature and to make minimal use of the multimedia sources. In fact, in the first phase of the study the multimedia sources of information with their stimulating visual and auditory qualities, were found to be a distraction rather than an aid in the information seeking process.. Group interactions have also been seen as a significant factor influencing the effectiveness of the individual's information gathering. When given instruction in ways to extract meaningful information, students have been observed to make more effective use of the multimedia information. The project has identified apparent limitations in the research skills of the subjects and future phases of the project aim to investigate whether multimedia sources in the form of electronic books can be used to enhance students' research skills and activities.

BACKGROUND

The multimedia applications that are coming into classrooms in increasing numbers hold some interesting prospects for teachers and students alike. A common application of interactive multimedia for education is the electronic book. This is the term often applied to the varying forms of databases that are developed with a multimedia format. Barker and Giller (1990) describe an electronic book as "a metaphor that is based on peoples' perceptions of traditional paper-based books." The difference between an electronic and paper-based book is that the paper renders the information "unreactive, static and invariant" while in the electronic book, the information is "reactive, variant and dynamic". The majority of interactive multimedia products with educational application are of this form.

The recent advancements in CD-ROM technology has resulted in the development of affordable hardware for school use and the consequent publication of a large number of interactive multimedia educational products. In 1993, it is likely to cost about $A1000 to add a multimedia pack to an existing computer system and about $A100 a copy for CD-ROM software titles. As CD-ROM drives are purchased in higher numbers, there is potential for their costs and that of the software, to diminish considerably.

As with many other computing products, questions remain as to whether new skills are needed to make effective use of interactive multimedia. Are conventional skills able to be adapted? Is it sufficient for students to simply know how to use the software to gather information from it? A useful parallel might be to consider driving a car. A person who has qualified for a driver's license may find a car quite useless in a city where he or she knows none of the streets. Even if the car is automatic, there is likely to be insufficient knowledge to make effective use of the vehicle.

INTERACTIVE MULTIMEDIA AND HYPERMEDIA.

Interactive multimedia and electronic books are an application of a relatively new form of media called hypermedia. Hypermedia is loosely defined as "a computer based software system for organising and storing information to be accessed non-sequentially" (Jonassen 1991). In early days, the information systems comprised mainly text and were referred to as hypertext. These information systems today combine a multitude of media as well as text and hence the term, hypermedia. The application of hypermedia in education and training has seen the development and implementation of many new instructional and learning designs developed from previous research and work into computer assisted instruction. Interactive multimedia, which is an element of hypermedia, has been defined as "the integration of audio, graphics, animation and text utilising the computer as a control and presentation platform" (Edgar, 1992).

LEARNER CONTROL.

A critical difference between conventional computer assisted instruction and multimedia, is in the sequencing of the instruction. In the design of interactive multimedia materials, the learner is given a greater degree of freedom in choosing the information and activities that comprise the learning task. These choices are typically non-linear in fashion (McGrath, 1992) and are controlled by a system of menus that enable the learner to navigate through the program. Learner control is an important consideration when considering learning applications of interactive multimedia. By their very nature, interactive multimedia products provide the highest degree of learner control possible. The hypermedia base on which they are designed relies heavily on a very low degree of program control and maximum opportunity for control given to the learner.

There has been considerable research conducted into the effects of learner control of computer based learning on the acquisition of knowledge. Not all research has been conclusive. Murphy & Davidson (1991) describe a study in which the development of concept learning was studied in relation to varying levels of learner control. Learner control was not found to be an influencing variable. Other research on learner control clearly indicates that learners who are not skilled in the subject tend to learn more effectively if the control of the learning sequence is left to an external agent rather than the learner herself. While skilled learners choose more options and make better use of the instructional materials to achieve higher learning gains, less skilled learners make poorer choices, choose fewer items and perform less well (Goetzfried and Hannafin; 1985, Ross, Morrison & O'Dell, 1989). The findings from such research suggests a need for caution and concern in the application of interactive multimedia materials such as electronic books among novices and less skilled learners. The lack of any form of program control over the material that is presented to the learner could result in many students failing to access important information from the program. The non-linear form of information access could result in learners choosing inappropriate information sequences incapable of delivering the information being sought.

The lack of program control in interactive multimedia applications is one of its key attributes and main strengths (Scott MacKenzie, 1992). If it is the case that unskilled learners do not fare well with such instructional design, then it is necessary to consider changes to the way learners use the programs rather than changes to the instructional design of the application. If learners can be trained in the processes involved in navigation and appropriate navigation strategies developed, the potential for successful use of the application would appear to be enhanced considerably.

EXISTING RESEARCH.

There has been a good deal of research conducted into computer based learning that can have direct application in the design of interactive multimedia materials. The Interactive Video (IV) has many parallels with modern multimedia applications and was an advancement with which much of today's technology is linked. These devices were used more for instructional purposes than as information sources but much of the research in this area has relevance to this study. McNeil and Nelson (1991) report a meta-analysis of instructional applications of IV over the past ten years. Among their findings concerning effective implementations of IV in classrooms are findings that suggest:

- the importance of the teacher in the learning process,
- program controlled producing more effective learning than learner controlled IV,
- a favouring of group instruction and
- learner differences contribute significantly to differences in learning outcomes.

COOPERATIVE LEARNING.

The use of interactive multimedia materials and electronic books is frequently completed in group settings to provide student access to what is frequently a scarce resource. The need for consideration of the students' discrete and combined actions in such settings would appear an important consideration in determining the learning potential from such activities. In some instances, the use of interactive information providers such as video-discs and CD-ROM, may not be well suited to applications of this nature.

At first glance, the use of interactive instructional materials appear to have considerable potential as facilitators and motivators of group activity. There has been considerable research conducted into the effectiveness of small group learning activities. Johnson and Johnson (1989) report a significant improvement in effective learning among students engaged in group learning when compared to individual learning. With computer based materials, the research once again indicates positive outcomes to be gained from the use of groups rather than individuals. Research indicates that computer based instruction is often more effective when completed in groups with the grouping able to yield improved achievement and attitudes over individual instruction (Dalton, Hannafin & Hooper, 1989; Hooper, 1992).

The achievement of improved learning outcomes through the cooperative use of computers is dependent, however, on the quality of the design of the computer based learning materials. Hooper (1992) discusses the need for the software to enable all group members to be cognitively engaged at all times in the learning process. Dalton (1990) argues further that the design of instructional materials for group activities demands inherently different approaches to materials used by individuals. The instructional design characteristics of interactive multimedia tend to reflect more the intention of individual rather than group use, in much the same way as printed material serves the single reader. The capacity of the materials to display and present information to the wider audience is a key factor in encouraging their group use. In assessing the utility and efficacy of the use of interactive multimedia materials, the nature of the interactions and outcomes from group use would appear an important and necessary consideration.

NAVIGATION.

Previous research projects conducted among varying applications of multimedia in the form of hypertext and hypermedia have shown that many factors can and will impact on the outcomes from the use the application of interactive multimedia in classroom settings Trumbull, Gay & Mazur (1992) found that the different search modes employed by users of interactive multimedia was a factor influencing the success of interactions. Jacobs (1992) questions whether educational institutions are ready for the open-ended nature of hypermedia applications bearing in mind the difficulties that have accompanied the applications of discovery learning.

THE RESEARCH PROJECT

A research team at Edith Cowan University has been actively pursuing research that seeks to determine the efficacy and utility of interactive multimedia applications in schools. To achieve this, the team has conducted several case study projects in which MPC computers (multimedia personal computers) have been placed in classrooms and a comprehensive evaluation undertaken of the use of these resources in student-centred research projects.

PHASE ONE

In the first phase of the study, the electronic book, Mammals CD-ROM Multimedia Encyclopaedia, was used by students in conjunction with conventional books as an information source for a project. The purpose of this research project was to investigate outcomes from the application of an electronic book as a source of information for classroom research. To achieve this the study sought to discover the following attributes of the use of electronic books in the context of an inquiry based student activity:

- the impact of total learner control on the quality of the information accessed,
- the information seeking and recording strategies employed by students,
- the forms of information accessed by students, and
- the nature of the interactions among students and the potential influence on learning outcomes.

The study was conducted in a class of 32 students in their final year of primary schooling. Two MPC systems running under Windows 3.1 with the Mammals program were installed in the students' classroom for the four weeks that the project ran. Students were rostered in groups to use the computers and given access to the computers on four separate occasions during the project. A cooperatively planned unit of work was developed by the classroom teacher and the teacher librarian and integrated into the Social Science Curriculum. The requirements for the project and the expectations of the teacher were made evident to the students in a session conducted by the teacher librarian at the commencement of the activity. The topic of Mammals was discussed and students given the opportunity to select a particular mammal as the focus of a research activity.

As the school follows an inquiry approach to research work, students were guided to create focus questions that would direct and lead their information gathering. Through the development of a concept map and class discussion, students were able to consider the nature of the material that would be useful in the required summary paper. Students compiled their own lists of focus questions under the guidance of the teacher librarian.

The students were given comprehensive training in the operations of driving the package. The students spent a number of designated library research periods over the period collecting information from which their summary papers would be written. This time was spent jointly in the library using books and in the classroom where the computers were stored. Data was gathered by the researchers through observation and videotaping of all computer interactions, follow-up interviews with all students and staff. Students' submissions were closely examined to determine the nature of the material that was contained and the level of use of information from the electronic book.

THE MAMMALS CD-ROM

The Mammals CD-ROM is an interactive multimedia computer program. It is published by National Geographic as an electronic form of a popular printed publication, Book on Mammals. The software has been designed with an instructional interface that gives full control to the user. All documentation for the program is in electronic form with help and instruction sequences readily available to the user. The program contains 44 colour video clips, in excess of 700 colour photographs and information on 229 mammals.

An initial screen provides access through a menu system to a help routine, instructions for use, specific mammal information, information about individual animals, a game and an option to quit the program. If students elect to find out information about a specific animal, the program uses a two level alphabetic index to enable selection. A species screen for each animal provides a picture of the animal and a small amount of general information. A further eight icons on the screen provide access to distinct forms of information at yet another level,

- a sound file of the animal's call,
- a video clip showing the animal in its natural element,
- a photo album showing still pictures of the animal,
- a distribution map,
- a set of tables showing statistics on size, reproduction etc,
- an essay about the animal, and
- a printout of the essay or captions.

Within these eight options, there are some that provide access to a further level. For example, when viewing the photographs of the animals, students can view captions for each photograph and can often access a sound track. In its operation, Mammals has 6 discrete levels. Navigation through the levels is achieved by the selection of icons. At each level, there is an icon to take students back to the previous level.

RESULTS

The following paragraphs contain a summary of the behaviours that were observed and provide some insight into the manner in which the Mammals program was used as an information source alongside the other materials.

1 . INFORMATION SEEKING STRATEGIES

The program was judged to be easy to use, by all students in the class. The point and click mode of operation and the icon based navigation, although initially unfamiliar to many students, were quickly learned and applied successfully to operate the program. On only few occasions were students observed to arrive at screens that were not expected. In such instances, this was usually brought about by inaccurate clicking of the mouse and an unexpected selection being made. The program operated in a totally reliable fashion and students were able to access precisely the particular menu or information screen that they sought. Despite what appeared to be a large number of levels, no student was observed experiencing any difficulty in moving between the levels and in selecting from among the options. Students were observed to move directly to the required options once a decision had been made to seek particular information. Once the information had been gained, the return to the species menu or the main menu to facilitate further selection was direct and efficient.

The information searching strategies that were used by the students when interacting with Mammals appeared to be directly related to the size of the group using the hardware. Distinctly different strategies and processes were observed among students working in groups of four and groups of two. When working in groups of four, the students shared control of the hardware by passing the mouse between themselves. A typical interaction would see one student use the mouse to select the mammal of his/her choice and use the available options to receive information on that animal. In the process of viewing the information on this animal, the students would take heed of suggestions made by other group member. These suggestions were of the form "let's hear it" or "look at the photographs" and "can we see the video?"

In groups of two, the students were observed to pay more attention to the mammal from their own project. Individuals took more time to view the information screens on their particular mammal. There was much less evidence of interaction in the small groups. The student with the mouse assumed a higher degree of control with the other acting in a more passive role. In both modes, there was still a noticeable reluctance on the part of the students to attend to textual information. Textual information was available in the form of an essay on each animal, captions for the individual photographs, descriptions of keywords and phrases and short descriptions in many of the information screens. Students were rarely observed to read from the screen despite the large amount of information that was presented in this way.

2. INFORMATION RECORDING STRATEGIES.

Students were not observed to make much use of traditional recording methods when using Mammals. There were only several occasions when students were observed to use pencil and paper to record information and in these instances, the recording was usually done as a consequence of a direct suggestion made by a teacher. This was in direct contrast to the many pages of notes that were gathered from paper books.

Pencil and paper recording was only ever used in the small group size. Students appeared to be quite sensitive to the needs of others in their group and for this reason were not inclined to take time in an activity that could not be judged as useful to the whole group. Students were very much aware that if they chose to record information, others would be left idle and made to wait. With the smaller group size, this problem was lessened and a small amount of recording was observed.

There were a number of other factors that lessened the utility of recording by hand. Much of the information did not lend itself to recording in this fashion. For example, the sounds of the animals, the graphs of animal sizes and the maps of distribution were all difficult to record. When pencil and paper was observed in use, the students took considerable time to record the information. It appeared quite a clumsy exercise. The computer and its peripherals took up much of the space on the desk and left little room for other materials. Operation of the program required that the pencil be put down and the hand used to control the program. Taking information from the screen and putting it to paper required large physical movements of the head. These factors all combined to lessen students' inclination to use this form of recording information. A more comprehensive set of printing options within the program would have been gratefully received by these students. The program only provided hard copy of the essay and picture captions.

Most students appeared to have no specific information seeking purpose in using the CD-ROM and for that reason, the screens rarely presented information that merited particular attention and recording. The most popular recording method was the production of a hard copy of the essay. All students gained a copy of this information on their mammal on the printer and used it extensively in the production of their final paper. The essay was judged by the students to be a very useful document. It contained a precise but comprehensive range of information and as the name suggests, tended to be a summary of all the information made available through the program.

3. NATURE OF THE INFORMATION ACCESSED.

Being a multimedia product, the Mammals CD-ROM provided access to information in a variety of forms. Attention was paid in the observations to the relative levels of access made by students to the different forms of information. When students chose information about mammals, there was a noticeable order in the choices made. The majority used the same order to access information. It was apparent different forms of information had different attracting powers and as a consequence, some forms were utilised more heavily than others.

SOUND.

Sound appeared to be the most singularly popular form of information. Sound was consistently among the first choices made by individuals. In all stages of the study, students rarely passed up an opportunity to have the computer speak to them or to have the sound of mammals played to them. The students' actions demonstrated that the novelty of the situation was a strong determinant in guiding their decisions to seek this information. For example, students frequently had the computer pronounce mammal names that were obviously well known to them. Having heard the pronunciation, the action was repeated and comments passed on the pronunciations. With animal sounds, students were seen to repeat noisy and unusual sounds and to be excited by sounds that attracted other children's attention and interest

VIDEO.

When available, the video clips of mammals were viewed. The video clips were the second most popular choice being viewed after the sounds had been dealt with. There was obvious disappointment among the group that the video clips did not have a sound track. In the first lessons, students in all of the groups were observed to fiddle with the loudspeakers and their cables assuming that it was a hardware fault that caused the sound not to be heard.

Although the video clips had a strong attracting power, they appeared to have only a small holding power. In many instances, the video clips were quite lengthy and students frequently became disinterested and easily distracted from the viewing. This was quite surprising because there was a good deal of action to be viewed and the video clips contained very useful material relating to the mammals. Some of the reasons that appeared to lessen the holding power of the video clips included:

- The small size of the video display. The program showed only a small screen with limited resolution. This did not compare favourably with the standard video format with which students were familiar.
- The lack of sound. Students were not used to video without sound. It appeared that sound must play a large part in holding students to video displays.

PHOTOGRAPHS.

Having accessed the sound and video images, the students generally elected to view the still colour photographs. The photographs held students' attentions and interests far better than the video images even though they did not consciously realise this. When viewing the photographs, students tended to discuss and chat about the pictures. There was quite a degree of activity when photographs were viewed with fingers pointing to the screen and suggestions being made to move ahead and to move back.

GRAPHICS.

Two options provided very useful graphical images about the mammals and these options were observed to be the students' next most popular choice. Students viewed the distribution maps of the animals and the charts describing their physical attributes. These graphs contained a wealth of information that would have been very useful in the production of the summary papers. Students were rarely observed to record information from these screens and in many cases did not appear to recognise the extent of the information that was displayed. The screens did not have a strong holding power and after cursory glances, the students tended to move onto the next item.

TEXT.

Textual information was the least viewed option and the last choice of students when moving between the information screens. In terms of use in the summary paper, textual information from the program as the most widely used form of information. Textual information was available in a variety of forms. There was an essay on each mammal, captions for each photograph and hypertext descriptions of keywords. There were no recorded instances where students read the complete essay on screen. On most occasions the essay was accessed and a hard copy obtained immediately.

HYPERTEXT.

The hypertext information was rarely used. It may have been that students did not require fuller descriptions of the terms because they were already familiar with them. More likely, it was that since students were not reading the text that appeared on the screen, they had no reason to view the descriptions and definitions of the terms that were presented. Even the short textual descriptions that accompanied the graphics and images on other screens were not well read. The photo captions were the most widely used textual form. They were short descriptions and were applied to photographs. Students were observed quite regularly to read the captions as they viewed the photographs.

Observations of the usage of the information forms, revealed some interesting patterns that are worthy of mention.

- Students' preference for information forms was influenced by the capacity of the form to cater for the group rather than individual needs. The sounds, the video images and the photographs each had capabilities to enable the interaction and participation of the whole group in the viewing process.
- Students are not inclined to read and digest information from the screen. When presented with a screen with varying forms of imagery, students appeared to be attracted to the most visually and auditorally stimulating information and tended to neglect other information that had no means to attract their interest.
- The only textual information that was read and digested was that which was brief in its extent and which students selected intentionally. The photo captions and species descriptions were examples of this.

The first phase of the project revealed that the information gained by students from this electronic book was considerably less than the writers and publishers may have expected. It was suggested to the researchers that this product is for adult use and it was not likely that children would make proper use of it. We could only speculate as to the usage that the students might have made of the available information from Mammals if it hade been presented to them in paper form. It would most likely have been much more.

It was also interesting to speculate on the level of unfocused browsing that accompanied use of the program. It appeared that the novelty factor of this new resource was a factor that limited its effective usage. The findings suggested quite strongly that students needed more guidance in the forms of information that were available in the program if a more effective implementation was to be achieved.

PHASE TWO

A second project was planned to investigate whether appropriate instruction might be useful in increasing the information access skills of students using this electronic book. The second study involved a replication of the first project in a similar class of students at another school. The two studies were conducted in a similar fashion in all respects except that the researchers provided instruction in data retrieval processes. This instruction discussed ways to listen to sounds and to create descriptions of what was heard. Students were told how to watch video clips and to observe movement and activity and to describe what they were viewing. Students were also told how to study photographs of animals and to extract and note relevant information.

RESULTS.

The results from this second phase are in the process of being fully investigated. It suffices to say that the value of the instruction on data retrieval was noticeable from the outset of observations among the students. The focus given to the ways in which information could be drawn from the multimedia sources saw marked differences in the ways that these students extracted information from the electronic book when compared to students from the previous class.

In the first instance, the students came to the computers with paper and pencil and ready to write. There was ample room provided in front of the machines to place the paper and to write. Many students had blank pieces of paper with organised headings with the intention of placing information from the electronic book into some order on their pages. Although there was a novelty effect in place as had been evident among students from the previous study, the students in the second phase concentrated directly on gaining information from the source. There was a distinct pattern of behaviour in which a screen was displayed and left showing while notes were taken. From this point a new screen was selected and the pattern repeated.

The sounds were treated as information and listened to attentively. All students wrote descriptions of the sounds and many were seen to replay the sounds several times to check the accuracy of their descriptions. There were no examples of browsing as observed previously in which many sought to locate the loudest and strangest sounds. Similar actions were observed as students watched and viewed the video-clips. Descriptions were written of colours, movements, and behaviour patterns. On many occasions, the video was played several times to ensure that nothing was missed and the written information was accurate.

The students were not observed to view the colour photographs with the same level of purpose and intention as the sound and video despite having been given similar instruction. The photographs were viewed and in most cases, information copied from the captions or the sound clips that accompanied them. There was little evidence among the students of an ability to view a photograph and to describe what was being seen. The passive nature of the information seemed to limit the students' attention and interest.

Observation of the notes taken by the students and the material presented in the final projects saw the majority of information gained from the paper book sources. Although the students had gained up to two or three pages of information from the Mammals program, this was not a large amount of information when compared to that collected from other sources. Most students had used up to 4 other books and had gathered the bulk of their information from these other references. This observation was not unexpected. It demonstrated that the students valued the information gained from all sources and did not necessarily give undue emphasis or credibility to that obtained from the Mammals program.

SUMMARY AND CONCLUSIONS

The on-going nature of this research sees many more questions unanswered and in need of further investigation. It was not the intention of the research to gather empirical evidence to demonstrate or prove any hypotheses but rather to gather information on students' interactions with interactive multimedia sources. It would appear from this research that effective use of electronic books requires more than just skill in using the program.

The first phase of the research found that information retrieval skills among the subjects were not well developed. It was evident that many of these primary level students were unable to gather information from sources that were not text based. The second phase of the study demonstrated that students are able to use sources of a multimedia nature if instructed in ways to achieve this. The results of the study showed that this was not a difficult task to learn and most students completed these extra information retrieval tasks quite successfully. It would appear that appropriate instruction to develop these skills would increase the level of effective use of electronic books in such settings.

Other questions that have arisen from this project concern the levels of research skills that were shown by the participating primary level students. It was evident in both phases of the study that very few students were doing any more than simply collecting volumes of data describing a chosen mammal in order to complete a well presented project. This was despite clear instructions and guidance in developing focus questions of a research nature. In both cases, the teachers wanted the students to do more than simply transcribe notes from one page to another. There was the expectation that students would frame questions and gather information to find solutions. There were few instances where students appeared to be able to do this successfully. Most answers to framed questions were based on conjecture and contrived reasoning rather than astute use of information.

Such programs as Mammals can provide an ideal environment for student research due to the reactive, variant and dynamic nature of the information. The organised nature of the information that is contained and the consistency of the display would appear to enable and facilitate information seeking that sought to identify patterns, to compare attributes, and to contrast variables, all of which are valuable research activities. It is the intention of the researchers in future studies, to use various forms of interactive multimedia to enhance the research skills of students. Such electronic books as encyclopaedias with full database searching facilities, would appear to be an ideal resource for such activities.

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USING A MICROCOMPUTER-BASED BULLETIN BOARD FOR COURSE DELIVERY AND STUDENT COMMUNICATION IN DISTANCE EDUCATION

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This paper describes a bulletin board set up for course delivery, and communication between participants, in a distance education unit. The bulletin board was designed for students enrolled in a second year unit in a Graduate Diploma in Computers in Education available only by distance education. This unit introduced students to database, spreadsheet and communications software and to concepts associated with systems analysis and design.

The purpose of the unit was to encourage students to think about the ways in which this software could be applied to administrative tasks in schools.

Several accounts of the use of bulletin boards and electronic mail in distance education have been reported (Dekkers & Cuskelly, 1990; Latham et. al., 1987; Moore, 1988). These use mainframe computers, and software which requires specialist programming skills in the design and maintenance of the bulletin board. The bulletin board described here, however, uses a microcomputer (Macintosh Plus with 20 Mb hard disk) and the commercially available software *Second Sight* (Watson, 1989). This "framework" software can be used to "customise" a bulletin board to suit the particular purposes of the unit adviser (lecturer-in-charge) of the unit. This paper: (a) outlines some of the ways in which this readily available and inexpensive[2] software can be utilised for educational purposes, and (b) reports on the use which students made of the bulletin board in a one semester unit.

THE STRUCTURE AND OPERATION OF THE BULLETIN BOARD

From the student (user) perspective there are two distinct phases in connecting with the bulletin board - (a) registering as a user and choosing settings so that the bulletin board will operate with specific hardware and software, and (b) using the bulletin board to download and upload files and to communicate with other students. These phases are described in the following sections.

REGISTERING AS A USER AND CHOOSING SETTINGS

When students connect with the bulletin board for the first time they must register as a user. This involves responding to questions which prompt students to state their name, password and the place they are calling from. They also make choices about the way the bulletin board will operate on their microcomputer - for example, the way text will be cleared from the screen, and whether menu choices will be reacted to immediately or confirmed by pressing the RETURN key first. After the correct options have been chosen the following menu is displayed on the screen.

```
= = = = MAIN MENU = = = =
<N>ew Password
<C>hange Terminal Preferences
<S>how Your Statistics
<I>nfo About Grad Dip In Computers
<D>isplay Welcome Message
<A>sk for Validation
<G>oodbye, log off the BBS

Command (N, C, S, I, D, A, G)?
```

Initially, students are only given a minimum clearance level; they cannot transfer files, or communicate with other students, until they have registered as a user on this bulletin board. To register, students must choose **<A>sk for Validation** from this menu. This facility ensures that only *bona fide* users are able to use the bulletin board.

DOWNLOADING, UPLOADING AND COMMUNICATING

When students contact the bulletin board as registered users, the MAIN MENU is displayed.

```
= = = = MAIN MENU = = = =
<N>ew Password
<C>hange Terminal Preferences
<T>alk to John now
<S>how Your Statistics
<I>nfo About Grad Dip In Computers
<F>ile Transfers
<P>ublic Messages
<E>lectronic Private Messages
<D>isplay Welcome Message
<G>oodbye, log off the BBS

Command (N, C, T, S, I, F, P, E, D, G)?
```

This menu differs from the menu displayed when students first connect with the bulletin board. The **<A>sk for Validation** option does not appear (since students are now registered users), and four new options are added which allow students to use the bulletin board. These options are described briefly here.

<F>ile Transfers

When this is selected from the MAIN MENU the FILES TRANSFERS menu is displayed. It looks like this:

```
= = = = FILES TRANSFERS = = = =
<N>ew Files Added Since Your Last Call
<L>ist All Available Files
<S>earch For Characters in File Names
<G>et File's Description & Other Info
<D>ownload a File from this BBS to Your Computer
<U>pload a File from Your Computer to this BBS
<E>xit to Main Menu

Command (N, L, S, G, D, U, E)?
```

Some brief comments on some of these options should clarify their purpose.

<N>ew Files Added Since Your Last Call

This signals new files (not messages) added. The unit adviser is the only person who can add files for students to download. However, files uploaded by students can be made available for other students to download.

<L>ist All Available Files

This provides basic information about the name, size, date added, number of accesses, and file type.

<S>earch For Characters in File Names

This enables students to obtain the correct name of a file for downloading.

<G>et File's Description & Other Info

This contains a brief description of the contents of each file.

<D>ownload a File from this BBS to Your Computer

This option is chosen to obtain study guides, resource material or other files from the bulletin board

<U>pload a File from Your Computer to this BBS

Students can select this option when they want to post an assignment.

<P>ublic Messages

When this option is chosen from the MAIN MENU the following screen is displayed.

```
= = = = PUBLIC MESSAGES = = = =
<P>ost a New Public Message
<S>can Public Messages
<D>elete a Public Message
<R>ead Public Messages
<F>ind a User's Correct Name (for Message Sending)
<E>xit to Main Menu

Command (P, S, D, R, F, E)?
```

The **<D>elete a Public Message** option can only be used by students to delete messages which they send to other students, or which other students send to them. They can only send messages to other registered users of the bulletin board - the option **<F>ind a User's Correct Name (for Message Sending)** enables them to check the spelling of other students' names. However, public messages can be addressed to all students (the only "non-existent user" to which messages can be addressed). Public messages are restricted to 40 lines.

<E>lectronic Private Mail

This option allows students to send private messages to other students. When this is selected from the MAIN MENU the following screen display results:

```
= ELECTRONIC PRIVATE MAIL =
<R>ead Private Mail
<S>end Private Mail
<L>ook for All Messages Addressed to You
<F>ind a User's Correct Name (for Message Addressing)
<E>xit to the Main Menu

Command (R, S, L, F, E)?
```

Students can only **<S>end Private Mail** if they know another student's correct name. If in doubt, they can use **<F>ind a User's Correct Name (for Message Addressing)** to get the correct spelling. Private messages are restricted to 40 lines.

<T>alk to John Now

This allows students to "talk" directly with the unit adviser. When students choose this option a "beep" sounds on the bulletin board to alert the unit adviser that a student wants to "chat". Alternatively, the unit adviser can interrupt what a student is doing on the bulletin board to "chat" (if they appear to be having difficulty doing something, for instance) Typed messages can be exchanged in real time. While students can select this option at any time it is dependent on the unit adviser hearing the "beep" and being available to "chat". Therefore, a specified time is also available one evening each week for students to use this facility.

MONITORING USAGE OF THE BULLETIN BOARD

The software used to create the bulletin board provides two valuable facilities which enable the unit adviser to monitor student usage.

First, if the printer is connected and switched on, each connection with the bulletin board is recorded, as displayed in the following example.

```
Connection made at 1200 baud on 12/02/91 at 17:21:38
MARY SMITH from BAIRNSDALE
Downloaded <HD:DOWNS:ASS2>
Logged off on 12/02/91 at 17:24:53
```

Second, a report can be obtained about individual users. The number of files uploaded and downloaded, and the number of private and public messages posted, can be readily obtained for each student.

Students are also presented with information each time they call about the use they have made of the bulletin board, as shown in the following example.

```
Connected on 10/13/91 at 13:17:59
You have called this system 45 times
You last called on 09/25/91 at 13:21:27
You have uploaded 9 files and have downloaded 17 files
You have sent 2 private messages and 3 public messages

No new messages have been sent to you since your last call
```

Alternatively, students can choose **<S>how Your Statistics** from the MAIN MENU to obtain similar information.

USAGE OF THE BULLETIN BOARD

In this section data is presented on the use which students made of the bulletin board.

Location of Students

The enrolled students (N=17) who contacted the bulletin board during the semester were located in Victoria (N=14), interstate (N=2) and overseas (N=1).

Hardware and Software

The hardware and software used worked reliably throughout the semester. The Macintosh Plus microcomputer, Maestro 2400ZXR modem and Rodime external 20Mb hard disk ran continuously from the 5th of February until the Easter break (17 April) - 1752 hours - and from the 27th of April until the end of semester on the 12th of June - 1128 hours.

The communications software (*Second Sight*) also worked reliably although initial problems with "scrambled" messages could only be overcome by installing a new copy of the software and rebuilding the bulletin board.

Data Transmission

Data transmission over telephone lines was generally acceptable. No problems were experienced between Churchill and Queensland (at 2400 baud), or between Australia and Japan (at 1200 baud). Within the state, however, several students found that error-free connection could only be made at 1200 baud.

Students who contacted the bulletin board with Macintosh or IBM microcomputers (and a variety of modems and communications software) reported few problems. Any initial problems were usually the result of their lack of familiarity with their own communications software. However, two students using older Apple // microcomputers and different modems experienced considerable problems. One student had to make repeated attempts to connect, while the other was never able to use the bulletin board successfully.

When file transfers (uploads) were initiated properly by students, the files received were generally error-free and printed successfully. Therefore, since uploaded files (eg, assignments) could be successfully printed, this would eliminate the future requests to students to also submit printed copies of their assignments.

Initial Contact

Table 1 displays the week in which students first contacted the bulletin board (by sending a message asking for validation as a user).

Table 1 Initial Contact

Week Number	Number of students
-3	1
-2	2
-1	2
1 (24 February)	2
2	6
3	1
4	1
5	1
6	0
7	0
8 (Easter)	0
9	1

Table 1 reveals that most students made use of the early opportunity to contact the bulletin board; by week 2 of the semester, 13 students (76%) had contacted the bulletin board. The others contacted later due to problems in obtaining access to a modem, delays in receiving printed material about how to contact the bulletin board, or relocation interstate.

File Transfers and Messages
Table 2 presents data on file transfers and messages for each of the 17 students enrolled in the unit.

Table 2 File Transfers and Messages

			Messages		
Student	Uploads	Downloads	Private	Public	Total
1	11	20	13	0	19
2	24	9	17	1	46
3	10	0	8	4	22
4	1	13	0	0	18
5	0	3	3	0	10
6	12	9	2	2	27
7	3	11	15	10	27
8	6	13	9	8	43
9	7	2	6	3	19
10	1	18	1	0	13
11	5	1	8	2	19
12	3	9	3	0	33
13	4	8	1	2	36
14	0	8	1	1	13
15	7	8	7	2	25
16	0	7	1	0	3
17	1	11	2	0	5
TOTALS	95	153	104	35	378

Table reveals that the 17 enrolled students made 378 contacts with the bulletin board in the period from 29th of February to 12 June. Many obviously welcomed the opportunity to communicate this way. The bulletin board enabled students to "keep in touch" and helped to alleviate the isolation many feel as "distance" education students.

Student Contacts Each Day
The printed output of student contacts with the bulletin board was also examined to determine the number of student contacts each day of the week. To reduce the amount of printed output which had to be examined, data was collected from Weeks 4-7 (23 March to 12 April) and 8-11 (27 April to 17 May), the three weeks before and after the Easter break. These data are displayed in Table 3.

Table 3 Student Contacts each Weekday

Day	Percentage	Number of Contacts
Sunday	20	33
Monday	18	29
Tuesday	15	25
Wednesday	22	36
Thursday	10	16
Friday	9	15
Saturday	7	11
TOTALS	101	165

Table 3 reveals that the most popular days of the week to call the bulletin board were Sunday, Monday, Tuesday and Wednesday. These days account for 75% of total calls.

Time of Calls

Table 4 indicates the time of day at which students called the bulletin board.

Table 4 Time Each Day of Calls

Time	Percentage	Number
0600-1159	11	18
1200-1759	27	44
1800-2359	52	86
2400-0559	10	17
TOTALS	100	165

Table 4 reveals that the most popular times each day to call were between midday and midnight - 79% of all calls were made during this period. The 10% of calls made between midnight and 6am were almost all made by one student overseas (Japan) when telephone charges were cheapest.

Time of Calls and Telephone Rates

Data were also collected about the time of day at which students called the bulletin board, and the STD telephone rates which were applicable at these times, to determine whether students used the bulletin board in a cost-efficient way.

Table 5 displays the relevant STD telephone rates (day, night and economy rates) and the times at which students contacted the bulletin board. Data from the period immediately before Easter (23 March - 12 April) were collected. Calls by the overseas student, and local calls, were excluded from this analysis.

Table 5 Time of Calls and Telephone Rates

Rates	Percentage	Number
DAY RATE	29	28
NIGHT RATE	31	30
ECONOMY RATE	40	38
TOTALS	100	96

Table 5 reveals that 71% of calls to the bulletin board were made during the times at which cheaper (night and economy rates) telephone charges applied. This indicates that the majority of students used the bulletin board in a cost-efficient way.

REAL TIME COMMUNICATION

Since most students were in full-time employment, there were few opportunities to "chat" during the day. Therefore, to enable students to use this facility the unit adviser returned to his office each Wednesday night. Many students became regular callers and a wide variety of course-related and other topics were discussed.

COMPUTER CONFERENCING

The bulletin board was also used for computer conferencing.

The **<P>ublic Messages** option allows messages posted by individual students to be read by all students. Therefore, the "conference" in interactive, much like a face-to-face discussion. However, the "conference" is asynchronous, since messages are posted for others to read later. The "conference" extends over several weeks rather than being limited to, say, a two hour face-to-face discussion.

Towards the end of semester an evaluation of the course was completed using this conferencing facility. Students were asked to comment on "the advantages and disadvantages of using the bulletin board for course delivery and communication". In a four week period, 10 students contributed 25 messages. This computer conference proved to be very popular with some students. It indicated the viability of a computer conference for on-line "tutorials" among distance students; clearly it could be used as an alternative to attendance at residential seminars.

SUMMARY OF DATA

The experience of using the bulletin board revealed that:

(a) downloading files from the bulletin board was an efficient and reliable way for students at a distance to obtain study materials;
(b) students made substantial use of the bulletin board to download and upload files, and to leave messages;
(c) students usually contacted the bulletin board between noon and midnight. The most popular days were Sunday, Monday, Tuesday and Wednesday;
(d) most students used the bulletin board in cost-efficient ways;
(e) computer conferencing could be an alternative to face-to-face tutorials;
(f) this method of course delivery was received positively by distance education students.

WHY USE A BULLETIN BOARD?

The outline given of the structure, operation and usage of the bulletin board, reveals the ways in which a bulletin board can serve various practical and educational purposes.

First, a bulletin board overcomes problems associated with long lead times for the preparation of printed study materials. Changes to study materials can be made "up to the last minute" before new students start to use the bulletin board. Changes can also be made during the semester and students can be notified of these using the "Public Messages" facility.

Second, students can use the bulletin board to obtain study materials when it is convenient for them to do so, rather than being forced to rely on a fixed schedule of despatch dates. This helps to cater for individual differences in rates of progress, since students can organise their study program around work, family and other commitments.

Third, a bulletin board provides a convenient way for students to contact the unit adviser responsible for the course, and for the unit adviser to contact students. Because "contact" is by messages left on the bulletin board, this asynchronous communication avoids problems involved in attempting to contact others when it is not convenient to do so. The "Public Messages" facility is particularly useful when students need to be notified of relevant matters (for example, the arrival of a set text at the bookshop).

Fourth, the bulletin board provides a convenient facility to enable students to communicate with each other. Students can address messages to all course participants or to selected others. This asynchronous communication is more efficient than attempting to contact other students by telephone. Moreover, it encourages students to pose problems without thinking that their queries may be resented; only those who can, or want to, make a response.

Fifth, students can submit their assignments using the "upload" facility. This enables students to spend the maximum available time on completing the assignment. When the assignment has been successfully uploaded, the student's communication software indicates that the file transfer has been successful. This is instant verification that the unit adviser has received the assignment.

Sixth, the bulletin board can be used to conduct conferences between course participants. A special feature of this form of asynchronous communication is the opportunity for critical reflection about, and thoughtful responses to, messages posted on the bulletin board. This conferencing facility, which is similar to those used in other distance education courses (Florini, 1990; Mason & Kaye, 1989), provides a useful method for course participants to "discuss" relevant issues when it is inconvenient to meet for face-to-face seminars.

While building a bulletin board can be time-consuming initially, this is a feasible way to deliver study materials to students studying at a distance. It is also a convenient way for students to communicate with each other.

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GENDER EQUITY. INTERPRETING THE PAST: IMPLEMENTING THE VISION.

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This paper considers the history of the Gender equity issue in Educational Computing. Specifically the transitional nature of the research is considered. The research itself is divided into three main phases which stress the changes in gender research from liberal feminist agendas to post structural objectives. Practical implications of the research are considered in their historical context, along with recommendations for the future.

INTRODUCTION

As we approach the twenty-first century the vision of computer education is becoming technologically more diverse. Breakthroughs in computer hardware are almost a daily occurrence. The appearance of the interface is being constantly reshaped by developments in Virtual Reality and further modified by pen based and voice recognition systems. These technological changes are materially demonstrable. It is obvious to most computer users that they are sitting in front of a different machine than faced them ten years ago. Likewise the change in the nature of the interaction they are having with the machine is apparent.

Less demonstrable, are changes in research directions. Even in cases where the evidence is right before our eyes, literally, the application of subtle changes can be difficult to discern. These changes in direction however can have a manifest impact on the teaching-learning interface and provide guidelines for practice, plans of action, and warning of potential problems.

As a means of considering the "vision" which is to be shared, the focus of this paper is the history of gender equity research in computing. It is proposed that the issue of gender equity, as with most research issues is not static, and that as with hardware and software developments constant reappraisal is needed in order to comprehend the changing implications for the teaching-learning environment.

PHASES OF RESEARCH

The paper divides gender equity research into three phases loosely based on both philosophical underpinnings and pragmatic outcomes. It is accepted that these divisions are often arbitrary. Indeed, it is not the purpose of this paper, in suggesting these phases, to imply that there is a fixed "chronology" of research in the area. The implication is that the research conducted in this field is frequently sequential in its shift through the three phases delineated below. This sequential shift necessitates the division made in an attempt to extract meaning from the gradual transition in the research's focus.

PHASE I.

Gender equity in relation to computing was a topic of research interest before computers became commonplace in schools. The research in the pre 1980 period focussed primarily on the computer as "another" technical device or as a mathematical / scientific tool. Both of these fields were rich in opinions, if not research, on the ability, or otherwise, of females to use technology and achieve in mathematics and science (Maccoby and Jacklin, 1974; also see Rossiter, 1982). This vision of the computer provided the focus for research on gender issues. The focus was primarily on what was happening.

Researchers began exploring what was happening in the computer field in relation to access. Drawing primarily on quantitative research, the existence of "a problem" in relation to computing equity was noted (Anderson, Welsh, and Harris, 1984; Becker, 1983; Fetler, 1983; Boss, 1982). The predominant theme of intrinsic differences found a voice in the now familiar "deficit model". The liberal feminist tradition was clearly evident during this phase of research which highlighted historical bias and inequitable access to machines and courses. The premise underlying the research was more often than not expressed in terms of deficit "what girls don't have."

PHASE II.

During the early 1980's there was an appreciable shift in the focus of gender research in the computing field. There was a growing belief that the computer was different from other "scientific and mathematical" tools. Equity papers began to appear which addressed computing as a cognate field independent of others. This independence necessitated a new approach to the equity issue. It was no longer sufficient, if it ever was, to accept the general findings of "technology" and "mathematical" studies. The concept that there were specific activities involved in the process of computing which contributed to gender inequity was emerging. Prominent among the early studies in this phase were works which addressed girls "non selection" of computing tasks and activity (Muira and Hess, 1984; Fitzgerald and Hattie, 1985). Again quantitative research methods were the primary tool of these researchers. These studies, and others like them which addressed enrolment figures in elective computing courses, formed the basis for the study of gender equity in computing for the majority of the 1980's. The new focus was brought about by attempts to explain the discrepancies between male and female participation in computing activities, despite an apparent equalisation in opportunity and access.

Questions were now asked concerning the nature of human computer interaction. Issues of magazines, such as Sex Roles and The Computing Teacher were dedicated to the equity issue. Student interactions were considered. Studies addressed issues such as attitudes to computing, and the formulation of these attitudes. Computing role models and learning styles were considered, imbalances in magazine articles and images were highlighted, the value laden nature of software was addressed, as was the nature of the computer curriculum itself (for example Slesnick and Brady, 1985; Anderson, 1987; Linn, 1985; Campbell, 1983; Chambers and Clarke, 1989).

Whilst the theories underlying these studies are drawn from a wide range of social, cognitive, psychological and feminist stand points, the vast majority can be divided into two groups. The first being the "deficit" model, so popular in the initial phase of equity research. The second being a process model. Importantly the equity issues being considered do not determine the group into which the study falls. Whilst certain topics are more likely to adopt one approach than another, it is the approach itself which is critical to this dichotomy.

Studies in the first group are in many ways similar to the studies described in Phase I above. They generally identify an area or areas related to computing and claim that an inequality in this area contributes to a reduced performance of a skill or behaviour by females.

A case in point is the type of study which concentrates on the lack of appropriate images of females in computer texts (for example, Sanders, 1985). The logic followed maintains that should there be an appreciable change in images there will be a consequential change in observable behaviour, for example an increased selection of computing by females. In this case the deficit, or "what females lack" is appropriate images and the remedy is, as always, to give females what they lack. Again there are strong links with liberal feminism.

The second type of study generally accepts a more interactive view of the variables at work. This type of study is also more likely to involve a degree of qualitative research. The process approach, as its name suggests, considers the processes at work on an individual in the context of the educational setting. The process approach generally considers one or more of the items (or their interactions) identified in Figure One. This approach in general rejects the deficit model outlined above. The alternative model often questions the validity of the outcomes themselves.

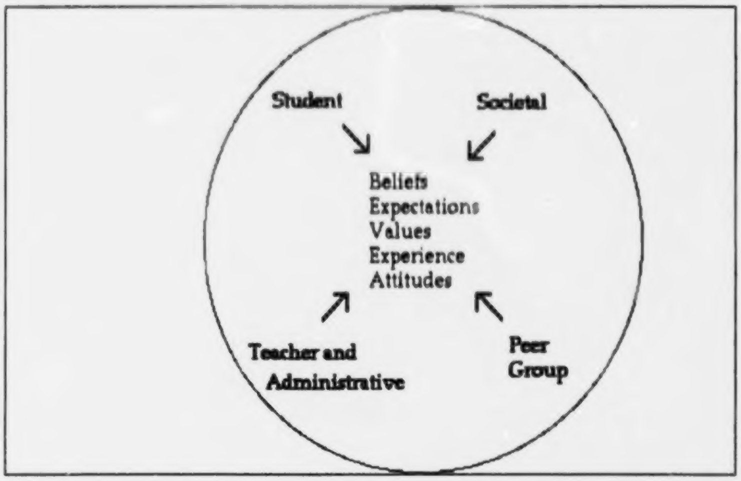

Figure One: Factors investigated by "Phase II" studies.

A case in point here is the consideration of value laden computer curricula. Studies of this type report that the curriculum has inherent biases toward male students. However instead of concluding that females are lacking something that allows them to take advantage of the opportunities presented it may be suggested that females are gaining different skills and knowledge which are just as relevant. It is the "system" either at the process or measurement stage which is "at fault" not the individual. The research in this field is ongoing and there is clearly much to be learnt from these studies. The 1990's however have seen a further shift in research emphasis.

PHASE III

The third phase of research into gender equity has continued the shift away from the individual in attributing causation in the equity debate. As noted above the first phase of research almost universally accepted that the equity problem was based with the individual. The individual females, or females perse, were lacking something which accounted for the equity problem. The remedy therefore was seen as supplying what was lacking, be that computer access or role models. The second phase generally shifted the emphasis one step away from the student. The curriculum or software for example was seen as the basis of equity problems. The third phase moves the equity debate one step further from the individual. Its focus is on the nature of technology and society itself.

This focus includes the association between technology and its social context as well as the ability of technology to dictate its own uses (Foster, 1992; Murphy, 1988; Bignum and Green, 1992). There is recognition that the development of computer technology prescribes certain uses. Drawing on the work of Turkle (1984) it has been argued that the development of computer technology, mainly by males, prescribes certain approaches which do not necessarily suit the relationship patterns females have been encouraged to develop throughout their lives. It is further contended that the "negotiable interactions" favoured by females are almost totally overlooked in preference to the "controllable interactions" which males are encouraged to develop within their social frameworks. Diagrammatically this widening scope is represented in Figure Two.

This third phase owes much to the more complex interactions addressed through the qualitative approaches adopted in many Phase II studies. It also owes much to the general increase in acceptance of qualitative studies. Likewise these Phase III studies draw more heavily on post structural (post modernist) feminist theories in their strategies for change. The important change in this stage is in the perception of the problem. It is not perceived by researchers in the third phase as exclusively a female problem. Therefore the nature of the research metaphors and intervention strategies are not focused on change in females. Rather than changing female attitudes to current technology for example, credence is given to the idea that the technology may be in need of change.

It is perhaps important at this stage to acknowledge the transitional nature of the "progression" through these

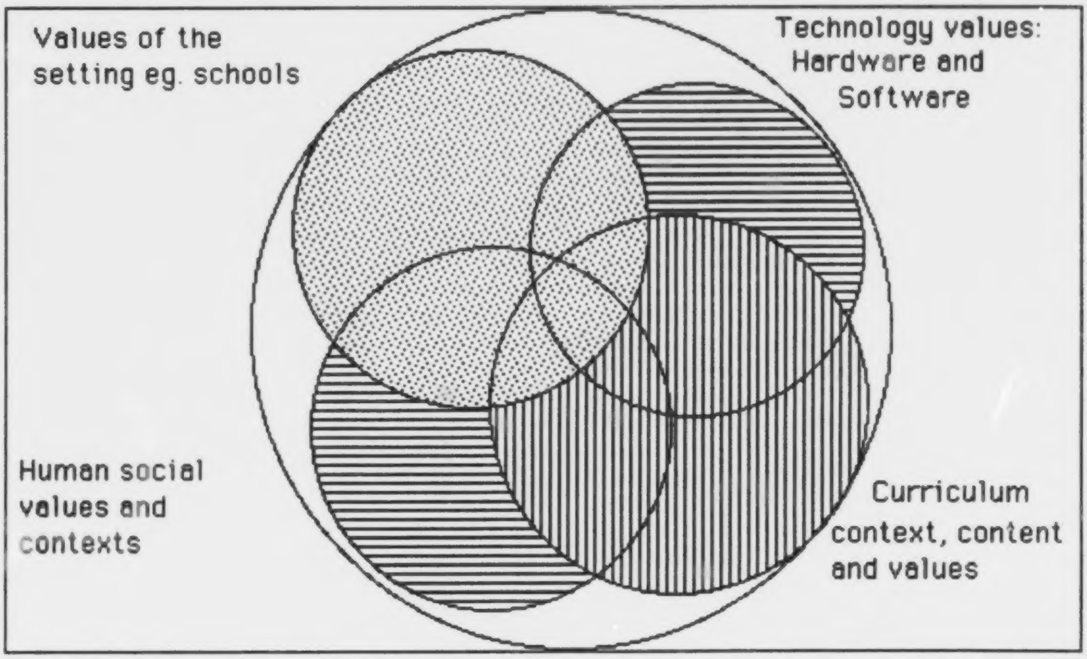
Values of the setting eg. schools
Technology values: Hardware and Software
Human social values and contexts
Curriculum context, content and values

Figure Two: Diagramatic representation of the increasing scope of gender research phases. Whilst they do, by necessity, reflect a chronological order, it is impossible, and in many respects undesirable, to identify precise boundary dates for any of the phases. This is for two basic reasons. First, it is not the intention of this paper to suggest that research of any of the three types identified above is no longer possible. Clearly this is not feasible. Secondly, the independent nature of the research process allows for wide variations in progression through the phases.

Take for example the pioneering work of Turkle(1984); conducted before an adequate picture of the equity situation in Australia existed. What is clear however is that there is a consistent trend, as is evident in most fields of research, towards a deeper understanding of the causal attributes of the issue under consideration.

This trend has led to a recognition that the variables and interactions between variables are more complex than first thought, and spearheaded the methodological changes evident in current research (Kay, 1992). This trend, and the accompanying research, has also led to a change in classroom and school based strategies for dealing with the equity problem.

STRATEGIES FOR CHANGE

During the first phase of the computer equity debate the solution to the equity problem appeared, superficially at least, to be clear cut. By supplying the necessary access to computers the problem would be solved. Females would overcome their deficit and take their rightful place beside males in the computer classes. School based strategies during this phase were typified by programs to increase female access to computing and raise the awareness of teaching staff about the equity issue. In some ways this was the easiest equity task to be performed. Schools implemented policies which were designed to give females equal access to computers. Sex based statistics were kept on enrolments in computing courses, and females were "encouraged" to take computing courses (Fish, Gross and Sanders, 1986; Clarke, 1986). The failure of these measures to impact significantly on the bias evident in computer access, usage, and course enrolment gave impetus to two groups of researchers. First, the supporters of intrinsic sex based differences saw this as justification of their standpoint. Research was conducted into exactly what characteristics or attributes were absent in females which led to this apparent anomaly (Feingold, 1992; Marsh, 1989; Jacklin, 1989; Martin and Hoover, 1987).

Secondly, alternative research paradigms emerged which investigated the way in which social factors influenced the computing context. Obviously, the failure of the "equalisation" measures was a necessary precursor to the shift in emphasis from the research delineating an inequity to research addressing why that inequity exists.

Intervention programs were undertaken at the school level. Some schools set up single sex computing environments. Consideration was given to the sex of computing role models. Schools made attempt to reclaim non-compulsory computing time from males. "Gender inclusive" curricula were devised in many school regions in an attempt to equalise participation in, and attitudes to, computing subjects (Sanders and Stone, 1986).

Again it appears to be the failure of these measures to redress the balance which is providing the spur for the new direction evident in current research. It is important to note here that the measures described above have not been ineffective. However the basic question as to what lies at the heart of continuing gender inequities remains elusive for most researchers. Similarly, the pragmatics of implementing effective teaching strategies appear equally as elusive for classroom practitioners.

The strategies which stem from the current research provide some guidance. Some success with the critical incident approach based in critical pedagogy theory has been reported in the feminist literature (Kirkup, 1992; Luke and Gore, 1992). Likewise, close evaluation of intervention techniques which address attitudinal and behavioural change in society has been useful, as has gender based evaluation of technology itself (Huff, Fleming, and Cooper, 1992). Success has been evident in many areas, most notably with "Gender inclusive" curricula initiatives (Foster, 1992).

CONCLUSIONS

The transition through these phases has important implications for equity research itself as well as for the teaching-learning interface. In research terms it is clear that studies typical of the first Phase which address the issue of what is happening in the computer field are now of limited value. In Australia, and indeed most of the Western world, the inequities are well known and documented (Sutton, 1991). Studies which focus on this area should be seen as providing updated baseline information as a springboard to more complex studies, or as "awareness raising" exercises. They are unlikely to provide new insights into the issue.

The most useful studies it would seem are those which fall into one of the following categories. From the research perspective, studies which attempt to address the relation of societal and technological factors to the process of gender positioning in individuals appears to hold great promise in understanding the true nature of inequity. Practically, close evaluation of the long term effects of intervention strategies would appear to provide the best guidance for practitioners.

As we move toward the twenty-first century the great dangers facing research into the gender equity issue are threefold. First, the perception of progress in the equity area makes it increasingly difficult to keep gender equity on the research agenda. Secondly, the increasingly complex nature of the variables being considered necessitate the utilisation of more intricate research models and methods. Finally the greatest danger of all; that we might fail to share the vision equitably.

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COMPUTERS IN AUSTRALIAN SECONDARY SCHOOLS

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There can be little doubt that the increasingly widespread availability of personal computers has had an influence on Australian secondary schools. It is almost impossible to imagine a modern secondary school without personal computers available for use in support of teaching. Provision of computer equipment and the spaces in which it can be used has absorbed substantial funding from government and other sources. It has also impacted upon the curriculum through development of new subjects and components of subjects and has required organisational adjustments to facilitate effective access to computers by students and teachers.

Given the hopes held for beneficial application of computers in education, the widespread belief that competence with computers enhances employment prospects and the substantial commitment of funds to educational computing, it may be useful to develop a global view of the availability and use of computers in Australian secondary schools.

BACKGROUND

The extent of expenditure on computers in Australian secondary schools does not appear to be documented in any single source.

Individual States have engaged in a variety of projects and the experience in Queensland is probably not atypical. Atweh et al (1990) noted that during the three financial years from 1988 the Queensland Department of Education budgeted for an expenditure of $20 million for a Learning Systems Project. Half of the available funding was allocated to establish Business Education Centres in each of the 230 high schools and secondary departments for which the Department is responsible. The remainder was used for other projects including the provision of Electronic Learning Centres, the promotion of computer related subjects in the curriculum and investigation of communication technology in distance education. An earlier initiative, the Computer Literacy Project, operating from 1984 had placed IBM compatible equipped computer laboratories in all state secondary schools at a rate of approximately 15 computers per 1000 students.

The House of Representatives Standing Committee on Employment, Education and Training reported (Brumby, 1989) that from 1984 to 1986 the Commonwealth Government provided $18 million via the States to promote student learning about computers. A considerable portion was used for the professional development of teachers in the use of computers. Noting that the "Australian school children with the greatest contact with computers appear to be in Tasmania, where the average ratio is one computer per 22 students", the Committee recommended that "sufficient government funds be provided to enable schools to meet the OECD target of one microcomputer per ten students by the commencement of the 1992 school year."

Pelgrum and Plomp (1991) reported the results of a 1989 survey of computer use in 19 education systems around the world. Systems represented in the survey were drawn mainly from Europe but included North America, India, Japan and New Zealand.

As might be expected there were significant differences in the availability and use of computers and the student:computer ratio varied from 12:1 (Canada/British Columbia) to 572:1 (India). Typical ratios were in the range 15:1 to 30:1. The majority of computers in most countries were characterised as 8-bit with only Japan reporting a majority of 80286 or other more modern equipment.

In reporting on curriculum uses of computers Pelgrum and Plomp noted that, with the exception of the USA where almost half of secondary teachers used computers in lessons, only a small proportion of secondary teachers used computers. With few exceptions usage of computers was more likely to occur in mathematics or science classes than in classes involving the mother tongue or other subjects.

Australia was not included in the study and so far as can be ascertained no comparable study has been conducted here. Some aspects of educational computer use in the Australian states have been described (Galligan et al, 1991) but with the exception of the ACT no quantitative data was provided which could contribute to a comprehensive picture of availability of computers and their patterns of use.

Vanzetti and Atkins (1992) investigated the availability and use of computers in ACT schools. They reported that while "computers had made a significant impact in the ACT school system" the impact varies from school to school with "most schools and teachers ... at the stage of deciding where the computer can fit within the existing curriculum".

Fowler (1992) obtained data from 49 secondary schools in Queensland, New South Wales and Western Australia. Almost all schools had computer laboratories with the predominant computer types being IBM compatible and Apple II series. Word processing was the dominant classroom use reported but the survey did not seek information about use related to specific curriculum areas.

Gloet (1992) surveyed 657 first year students undertaking an introductory computer unit at the University of Southern Queensland. Surprisingly, of a total of 175 students who reported never having used computers at school, 52 were under 20 years of age and could reasonably have been expected to have had some experience of computers during their secondary schooling. For those who did use computers at school the most frequently mentioned curriculum areas (from most to least mentioned) were Mathematics, Computer Studies, Business Education and English.

A previous paper (Albion & Roberts, 1992) has described nationwide patterns related to computer programming in secondary schools. The data, obtained from a survey of schools participating in the Australian Computer Competition, included information on the types of computers used in the competition. However, the survey did not seek information about the computer equipment available in the schools for teaching purposes or the uses to which it is put.

This paper reports on the results of a subsequent survey which sought to elicit information about the availability and use of computers in Australian secondary schools.

METHODOLOGY

The Australian Computer Competition has been conducted through the University of Southern Queensland since 1983. It offers students an opportunity to work individually or in teams to solve challenging programming problems. In recent years the competition results have been used as a selection basis for Australian teams to compete in a regional competition. Competition organisers seek to reach every Australian secondary school with the annual mailing of invitations, presenting a valuable opportunity to gather data about computing in secondary schools.

The 1992 mailing included a two page questionnaire directed to computer coordinators. The questions sought information about the school, the coordinator, use of computers by teachers generally and in curriculum areas, availability of various types of computer hardware in the school and exposure of students to types of computer applications and to use of computers in specific curriculum areas.

Because the subjects taught vary widely across schools and states questions about curriculum were keyed to the broad curriculum areas selected by the Australian Education Council for development of national curriculum statements.

Because the survey was directed to "computer coordinators" and was associated with a computing competition it is possible that some degree of self selection occurred among respondents. Thus it is possible that schools from which responses were received exhibit more than average interest in the educational application of computers and may have higher levels of computer availability and use than the entire population of schools. Moreover, the responses concerning computer use by teachers reflect the perceptions of the computer coordinators rather than "hard" data. For these reasons the results reported here should be regarded as indicative rather than definitive.

RESULTS

Responses were received from 245 schools reporting total enrolments of 67175 boys and 67809 girls. This represents approximately 10% of both Australian Secondary Schools and their total enrolments (Castles, 1992). The respondents included 147 Government, 47 Catholic and 51 Independent schools of which 194 were co-educational, 29 were girls only and 22 were boys only.

While male teachers comprised 48% of all teachers (N = 11398) in the respondent schools 72% of the computer coordinators (N = 243) were male. The substantial difference suggests that the perception of computing as a male preoccupation remains a force to be reckoned with.

Of the responding coordinators 139 indicated that they possessed some qualification in "educational computing" with the distribution shown in Table 1.

Figure 1 shows overall percentages of teachers perceived by coordinators to match four broad categories of computer use. While it is disappointing that many teachers (44% of females and 37% of males) "make no use of computers" there may be some comfort in the fact that a majority of teachers do use computers and almost one in five has been classified as a "regular and effective user".

Qualification	Number
No response	106
No qualification	8
Inservice courses	2
Certificate / Associate Diploma	3
Post Graduate (Diploma or Masters)	68
Major in Undergraduate Degree	16
Minor in Undergraduate Degree	16

Table 1: Qualifcations in Educational Computing held by Computing Coordinators

When it is considered that it is only in recent years that improvements in software and decreases in costs have made computers widely accessible it is evident that teachers are making substantial progress in their computer expertise. The differences between male and female teachers evident in the graph are not statistically significant.

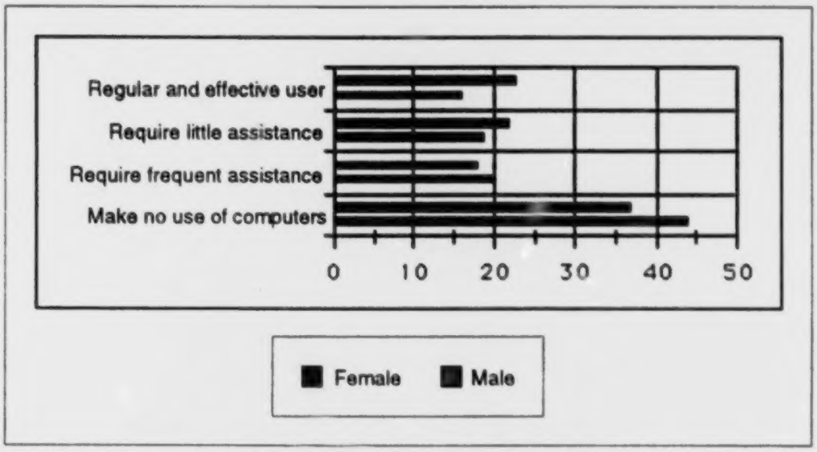

Figure 1: Computer usage by teachers

The type, as well as the quantity, of available equipment impacts on the ability of teachers to utilise computers in the curriculum. Figure 2 displays the total numbers and types of computers identified by coordinators as "used by students for instructional purposes". In total the number of IBM compatibles is approximately equal to the combined numbers of Apple II series and Macintosh computers with other types being generally less significant.

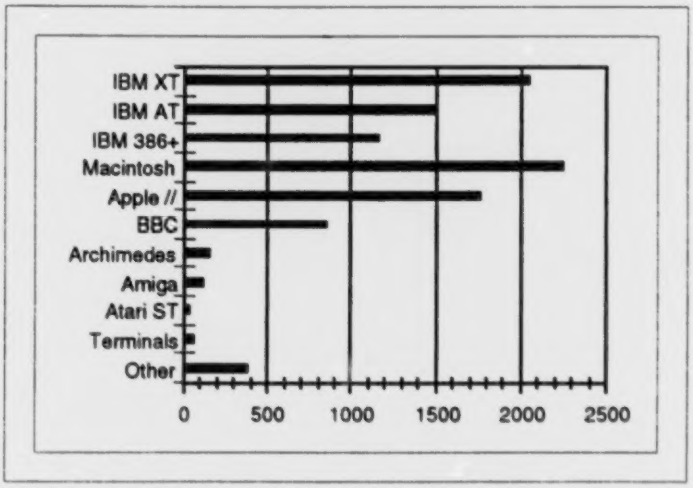

Figure 2: Computers used for instruction

The results of a decade of technological advance beyond the Apple II series and the IBM XT are evident but these marques are still prevalent in schools. Data gathered in the 1991 survey (Albion & Roberts, 1992) revealed that almost 40% of computers in 61 New South Wales schools were of the Apple II type. It might be assumed that schools will experience problems with reliability related to aging components and compatibility due to newer software being inadequately supported by older platforms.

An indicator of trends in usage patterns may be found in Figure 3 which shows the proportions of different types of computers which were reported as networked. As might be anticipated, computer architectures which encourage networking (Macintosh, BBC and Archimedes) are most strongly represented. Newer computers such as 386s are more likely to be networked and this trend will probably continue.

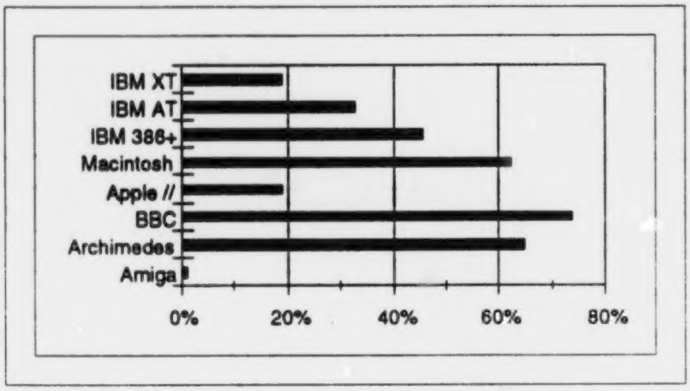

Figure 3: Percentage of computers networked

Overall the mean student:computer ratio was 14.35. Some 80% of schools had a ratio of 20 or less with the median value being approximately 12. Forty-three percent of schools were at or below the OECD benchmark of 10. Comparison of school enrolments and student:computer ratios suggests that small schools tend to have very low ratios and these instances tend to skew the distribution.

Mean ratios for coeducational, boys only and girls only schools were very similar, ranging from 13.14 to 14.60. However, variations across states and types of school were more notable and are shown in Tables 2 and 3. Students at Government and Catholic schools appear to be disadvantaged relative to those at Independent schools.

Type of School (N)	Mean Ratio
Government (135)	15.74
Catholic (44)	14.50
Indepen dent (47)	10.23

Table 2: Student:Computer ratio by type of school

It appears that Tasmania may have maintained its earlier lead (Brumby, 1989) and now has a very favourable ratio. The ratios reported for New South Wales and the ACT are markedly higher than for other states and the NT. Recalling the earlier result which indicated a large proportion of Apple II computers in NSW and allowing that the respondent schools are probably those most interested in computing there may be reason to believe that students in NSW and the ACT may be relatively disadvantaged in terms of access to computers.

State or Territory	Mean Ratios
ACT (8)	19.00
NSW (88)	18.19
NT (3)	7.67
QLD (23)	9.95
SA (15)	10.27
TAS (9)	7.67
VIC (53)	12.94
WA (27)	12.22

Table 3: Student:Computer ratio by State or Territory

The location of computers in a school is a significant factor in their accessibility to teachers and students. Responses indicated that overall almost four times as many computers were to be found in laboratories as in standard classrooms.

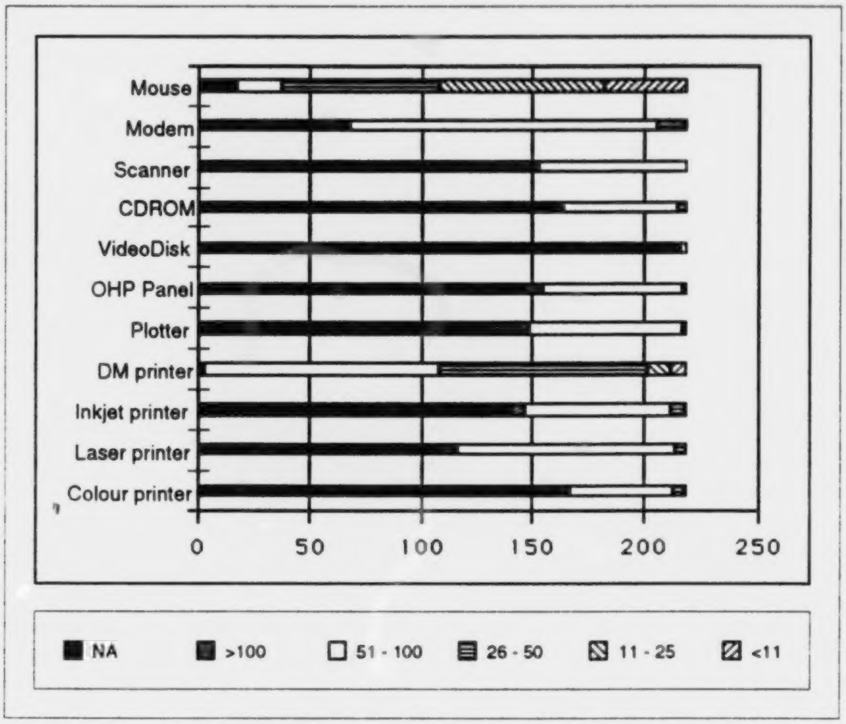

Figure 4: Distribution of student:peripheral ratios

The graph in Figure 4 shows the distribution of student:peripheral ratios for a variety of peripheral items found in schools. NA indicates that peripheral is not represented in a school.

Clearly the most widely available peripherals are the dot matrix printer and the mouse. Higher quality printers are fairly widely available and more than a quarter of schools have scanners. However, colour printing is not widely available, a result which is not surprising in view of the cost of this emerging technology.

The general availability of modems suggests that a significant number of schools may be placing a moderate emphasis on telecommunications.

Very few schools appear to have invested in the first wave of multimedia as represented by videodisk players but the appearance of CD-ROM players in significant numbers suggests future developments in this area may have a higher uptake rate.

The survey sought information as to the proportion of students (all, some or none) "who receive instruction in each type of computer application" at each year level. The responses can be interpreted very broadly at best but do offer an indication of the type of work being attempted in schools.

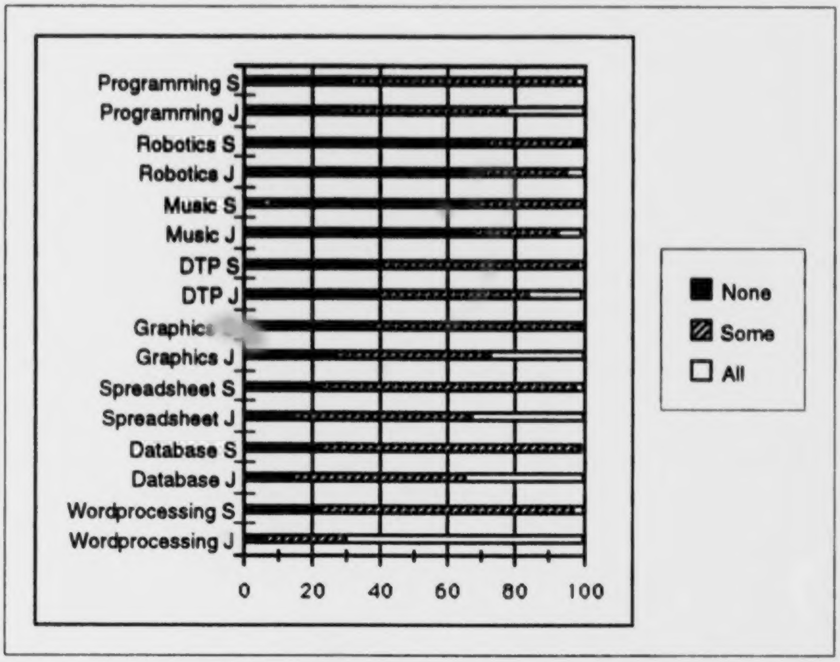

Figure 5: % of schools instructing at Senior (S) and Junior (J) levels

As is evident in Figure 5, word processing is the application most widely taught and is most often dealt with in the Junior (Years 7 to 10) classes. While database and spreadsheet applications are less frequently taught in Junior classes, at Senior (Years 11 to 12) level they rival word processing for frequency of treatment.

A surprisingly large proportion of schools provided instruction in programming at both Junior and Senior levels. It might be argued that association of the survey with the Australian Computer Competition would tend to bias responses in this direction. However, all secondary schools were invited to respond to the survey and most who did so seemed to do this independently of competition entries.

The number of schools where all students are receiving instruction in word processing drops dramatically at the Senior level although the majority of schools provide instruction for some students at this level. The probable interpretation is that all students receive basic instruction and some receive extended career related instruction.

No application is treated more widely at Senior than at Junior level, indicating that schools place more emphasis on computing for the general student population at Junior than at Senior level.

Coordinators were asked to indicate for each year level the proportion (all, some or none) of students who "use computers in each subject area". Figure 6 shows the proportions of schools reporting use of computers in each of the broad curriculum areas. To facilitate comparison among curriculum areas, some of which are taught more widely than others, the responses have been represented as a percentage of schools responding for each curriculum area.

Given that "Technology" includes computer studies it is understandable that more than 40% of schools reported all Junior students using computers in this curriculum area.

Interestingly the curriculum area in which the largest proportion of schools reported some or all students using computers is Junior English. This is consistent with the widespread use of word processing which lends itself to application in English. However, the level of computer use for English is substantially reduced at the Senior level. The international survey (Pelgrum and Plomp, 1991) found that a relatively

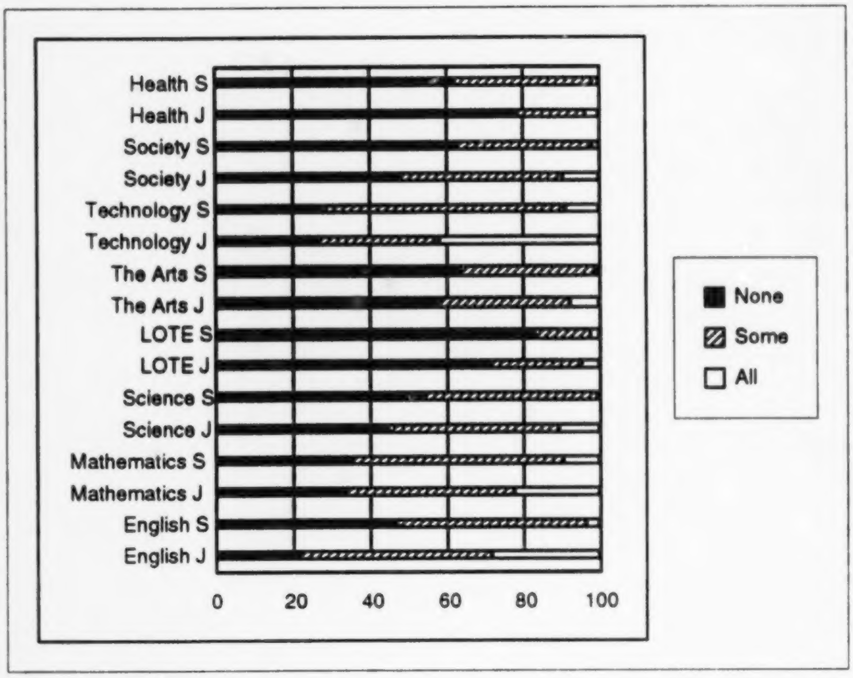

Figure 6: Percentage of schools using computers in curriculum areas

high proportion of teachers of Junior English in New Zealand used computers but that with the exception of the USA computers were not otherwise widely used in teaching of the mother tongue.

The only curriculum area in which computers are used more widely at Senior level than Junior appears to be Health. This contrasts with the international results (Pelgrum and Plomp, 1991) in which the tendency was for teachers to use computers more in the Senior classes than in Junior.

CONCLUSION

It is evident that secondary teachers in the sample schools are adapting to the availability of personal computers as tools of their trade. Over half of these teachers use computers and they use a variety of applications packages across the full breadth of the curriculum.

However, computer coordinators perceive that significant numbers of teachers are not effective users of computers and have identified several curriculum areas in which computers are relatively little used. While the coordinators may be able to assist in raising the skills level of teachers they generally have limited time and resources with which to do so.

The previous Commonwealth funded project for professional development of teachers in the use of computers was conducted in the early phases of school computing. Computers available at that time were prone to be viewed as overtly "technical" and there was a dearth of suitable software. Computers are now more widely available, operating systems are more easily approachable and there is a wide range of general purpose and educational software. A renewed professional development effort in computing should have an increased chance of success and ought be accorded priority in funding for teacher development.

Students in the sample schools generally enjoy a level of access to computers which compares favourably with that reported for other countries (Pelgrum & Plomp, 1991). In a significant number of schools the ratio of students to computers is better than the OECD benchmark of 10:1. However, some students have significantly lower levels of access and much of the available equipment is becoming obsolete to the point where it may be unable to support much of the educationally useful software which is now available.

If $3000 is taken as an estimate of the cost of acquiring a computer for school use and a useful life of three years is assumed, the OECD target of one computer per ten students could be met for an expenditure of around $100 per student per year. This represents a relatively small portion of the more than $4000 per student annual cost of secondary education. (Lonergan, 1992)

So long as most computers in secondary schools tend to be placed in computer laboratories the provision of rooms for this purpose imposes an additional cost which may be a powerful disincentive to increasing the numbers of computers available.

The debate about laboratory or classroom placement of computers continues to be aired elsewhere (Maddux, 1991) and it is not necessary to recount the arguments here except to note that placement of computers in laboratories may discourage their use other than for specialist purposes. Alternatives such as distributing computers into classrooms with network links may be more effective both in cost and educational terms if it promotes more effective integration of computers into the curriculum.

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ASPECTS OF GENDER AND COMPUTING PARTICIPATION

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In recent years, a number of writers, including Clarke (1990) and Thurston (1990) have discussed reasons for the low participation in computing by girls. Van Alstyne (1991) found that boys are more likely than girls to use computers outside school hours, and it is possible that factors outside the classroom are critical in trying to understand an apparent lack of interest by girls about computers. Salpeter (1992) has reviewed some of the existing research on computers and education. She concludes that:

> The gap between male and female attitudes and behaviour was most pronounced in studies that dealt with junior high and high school students...the tendency for girls to lose interest and become less confident about their abilities closely parallels what happens to girls attitudes towards maths and science at the same stage of their lives..it does seem clear that the strongest factor at work is social and peer pressure. (1992, p. 66)

Gorman's recent research which has recently reported on the biology of the brain, (1992) suggests that gender differences may be attributed, in part, to physical difference. This research does not, however, attempt to offer a complete explanation of the different behaviours of boys and girls. While acknowledging that the social and peer pressure referred to by Salpeter involves far wider issues than the use of computers in schools, it is possible to suggest how such pressures may be maintained and reinforced, and, in so doing, begin the task of making computer participation more equitable. This paper argues that three factors can be identified as possible contributors to the low participation rate of girls. These factors include the prevalence of feature films or videos which portray computers as a male domain, the nature of computer adventure games, and amusement arcade computer games, which are played mostly by males.

Before students enter a classroom, their attitudes to computers may well have been affected by role models who are seen to interact with computers. They will have seen both males and females in these situations. Such contexts may include viewing of videos or films which portray computers, the use of computer adventure games at home, and observation or play in amusement arcades with computer games. These contexts and their probable importance are discussed in this paper. It is not suggested that these contexts cover all possible aspects of role modelling of computer use outside the classroom, but rather that they may be indications of influences on the behaviours of boys and girls which have not always been well recognised.

1. FEATURE FILMS

There are a number of films available for hire from video shops which involve characters interacting with computers. It is interesting to examine some of these films to see how men and women (and students, male and female) are portrayed.

One of the earliest films dealing with computers, which is still readily available in video shops is the Stanley Kubrick classic 2001: A Space Odyssey (1968). In this film, we meet a computer with a male name and voice (HAL - 9000), which interacts with male astronauts and other male computer experts. Women are not seen as important where computers are concerned. The 1984 sequel, 2010 - The Year We Make Contact, also manages to marginalise women and their relationships with computers in a similar way to its predecessor, sixteen years earlier. If nothing else, it demonstrates that although there had been changes in computer education during this period, the influence of these changes had not yet permeated Hollywood. Girls who viewed either of these two films could form the opinion that, although great changes are anticipated in computer technology in the future, the role of women in the year 2010 has made little advance. In retrospect, we can understand the view of women and computers presented in the Space Odyssey films, if we remember that the 1984 film needed to have some consistency with the 1968 film. The 1960's were a time when the PC revolution had not yet happened, and the role of men and women in society could be seen as different to that of today.

To some extent this is also true of the next film. The Computer Wore Tennis Shoes. (1970) is a disney film which tells the story of a male college student who is "zapped" by a computer, and then becomes very knowledgeable. The writer, producer, director and star of this computer are all males. This was one of the oldest films examined for this research, and it shows a single mainframe computer being used by a male teacher at the front of the class. Not only are there no positive role models for girls in this film, but computing is seen as something akin to a priesthood, where the patriarchal teacher figure dispenses such information as necessary to the underlings. In terms of computer use in education, this film provides an interesting comment on how technology and pedagogy are inter-related. It was a time when computers certainly didn't sit on every student's desk. However, the technology had certainly changed by the 1980's, when another film depicting students and computers, War Games, was produced. By this time, it was possible for teenagers to use a computer at home to contact the world, and for individual computers to be appearing on student's desks at school. However, it remained to be seen whether Hollywood would portray boys and girls as having equal competence and access to computer technology.

War Games (1983) still makes interesting viewing, ten years on. It is a story of how a teenage computer hacker, David Lightfoot, triggers off the count-down to World War III by his illicit computer activities. The main character is male, and is seen to have typical hacker behaviour, as described by Landreth (1964) including skipping school, meals and sleep in a fanatical devotion to the computer. An FBI agent, who features later in the film describes Lightfoot as " intelligent, an underachiever, alienated from his parents" and, one could add, male. His girlfriend, Jennifer Mack is an underachiever in school, who is rebuked by her teacher for not paying attention in class. David and Jennifer have something in common - they have both received an F for their last work in class. This is not a very positive image for either male or female students who may be interested in computers. Students who saw this film could reach the conclusion that successful students may not be those who are interested in computers

Jennifer is more interested in people . "What's so special about playing games with a machine?", she asks. The message of this film appears to be that girls are not interested in computers, and girls who are interested in boys who use computers will end up with less than satisfactory boyfriends. The computer has a male name (Joshua), and has been programmed by Dr Stephen Falken. When David needs assistance to break into the computer, he turns to two men for assistance. Jennifer, who is with him at the time, is made to stay in the background. The implication is that girls would not understand computers and could not be trusted with information concerning them.

The wider message of the film is that computers cannot be trusted. Professor Falken, who had originally programmed the computer which is now threatening to destroy the world, had been trying to teach it that, with war as with the game of Tic-Tac-Toe, the game itself is pointless. The computer eventually concludes that "the only winning move is not to play" . It would not be surprising if some girls were to reach a similar conclusion about their involvement with computers. The attitude implicit in this film towards the capabilities of girls and computers is not restricted to War Games. In the next year, 1984, the stereotype of men as the gender interested in computers, and women as the gender interested in relationships gained further support in the film Electric Dreams.

In this film, described by Brown's Rating the Movies (1990) as "silly and preposterous", an architect, Miles, competes with a computer for a girl's love. The girl, Madeleine, is seen as sensitive, but not really interested in computers. Miles, who could be described as a "nerd", is particularly clumsy, The computer eventually self-destructs to preserve the relationship between Miles and Madeleine. One interpretation of this film is that girls are, by nature, more interested in relationships than computers. Girls who become involved with boys who are interested in computers will end up with a "nerd". Translated to a classroom situation, it would not be surprising if girls were less likely to be involved with computers, or with boys who were interested in computers. The idea that computers are alienating for girls is reinforced in the first five minutes of the film, where a brief cameo shows a girl using a computer and being told that she is too fat. Such episodes would be likely to persuade girls that it is unlikely that they could interact satisfactorily with a computer, or use one without embarrassment.

Films made around the mid 1980's portrayed a recognisable series of stereotypes. In essence, a clever boy is able to do unusual things with computers. Women and girls, in this version of reality, are seen as incompetent, or as domestic servants. This may be seen as a variation of the image of women presented in previous films, where women are more interested in relationships than in technology. D.A.R.Y.L (1985), is an example of a film involving computers which presents women in this way. It tells the story of a strange boy, who is a computer whizz. The acronym is short for Data Analysing Robot Youth Lifeform, and

Daryl is later found to be a robot. The role of women and girls is peripheral in this film. They are portrayed as mothers, who work in the kitchen, or, in the case of girls, as part of a group of young women who are less capable than Daryl.

The theme of D.A.R.Y.L. is continued in two further films of the same period. I.F.O and Computer Wizard continue the now familiar concept of intelligent boys who are able to do clever things with computer technology. I.FO (Identified Flying Object) is a 1985 film about two boys who liberate an advanced, computerised, helicopter. One of the boys has a sister who owns a computer, but she is portrayed as less competent with computers than her brother. Girls have only insignificant parts in this film. Computer Wizard is also a story about a school-age boy and computers. Willie is shown to be particularly clever with computers. His dad presumably wants him to grow up to have similar interests to his own, and together they share pursuits such as shooting. Female role models in this film are limited to Willie's mum, who is usually associated with meal preparation for men, and a fat lady who screams a great deal when alarmed by Willie's computer pranks. Girls who lack confidence in the use of computers are unlikely to gain encouragement from this film. Conversely, some boys may be reinforced in their belief that computers are interesting and manageable.

Some slight change in attitudes can be seen later in the decade of the 1980's. The Adventures of Max Headroom (1987) provides a partial relief to the lack of female role models with computers. A strong female support is provided in Amanda Pays, who is an expert in computerised news technology. Amanda provides a positive role model, of a person in a senior position who is competent, decisive and independent. She is quite at home with computer technology, and this is a refreshing change to some of the earlier films described in this paper. However, the most memorable character is a computer-generated male character, Max Headroom. Combined with the typical computer whizz-kid (a boy) and a strong male lead, Edison Carter, it seems unlikely that adolescent girls would have their confidence in computer use boosted in this film, as the competent female image is overshadowed by males involved in computer technology. It is, however, interesting that the most recent film reviewed for this research showed some indication of awareness that women can be seen in a positive role where computers are concerned. This may demonstrate an emerging awareness that the roles of the people associated with computers need not be restricted to males.

It is more than possible that films reflect community attitudes towards issues such as the position of men and women in society, and the jobs and attitudes which are thought to be typical. It may be that, as films more recent than 1987 find their way into video shops, the changing roles of men and women will be reflected in them. One could list a number of other films concerning computers where women and girls have only a marginal role, or are seen as less competent than males. These might include THX 1138 (1971) Tron (1982), and The Last Starfighter (1984). The impact which the preceding films might have on the participation rate of girls in computing is admittedly speculative. Although it may be difficult to prove that a particular film has influenced a particular group of boys or girls, it is more reasonable to assert that, whatever feature film concerning computers is watched, it is likely to contain negative role models for girls. As Sachs, Smith and Chant (1991) have demonstrated, the viewing of videos is important in the media tastes of adolescents.

These comments, of course, are not applicable to educational or documentary films, where the films' purposes may include the raising of consciousness of some groups, including girls, towards computers. Perhaps one step towards having a more positive representation of girls and computers in films is to make teachers and their students aware of the current situation. If filmmakers find that audiences are becoming so sophisticated that they reject the stereotypical images which were characteristic of the 1970's and 1980's, the nature of the discourse may change enough for there to be some educational advantage. While this is one possibility, we may never know whether films reflect society's attitude towards women, or whether they shape it. If it is the former, then we may see changed attitudes towards women in films in the near future. If it is the latter, then the films may change only when the producers realise that both men and women may not pay to see films which represent women in unacceptable ways.

2. COMPUTER ADVENTURE GAMES

Computer adventure games are available to many students, at home and at school. Regrettably, many of the available games, particularly commercial ones, are violent and sexist, and it is likely that exposure to them would reinforce boys in attitudes towards women and girls which some might describe as undesirable. The last few years have seen a continuation of the phenomena which meant that more computing power is available for less money. Increasingly, computers are to be found in student's homes, and in their classrooms at school. Concurrent with the growth in hardware has come the rise of the software specialist. It has become common for major shopping centres in capital cities to have a software shop, which sells entertainment, educational and business software.

Five years ago, such shops were much less common. That there could be several chains of shops competing to sell software, much of it for home use, indicates confidence in the size of the market. The importance of such confidence should not be overlooked. It suggests that a considerable quantity of entertainment software is destined for home use. As computers become more common household items, the software which is purchased for their use will be critical in the determination of attitudes of members of the household towards them. Software, of course, reflects what is perceived to be the needs of the market. If the software to be found in homes is aggressively violent and sexist, rather than problem-solving and gender-neutral, the attitudes of boys and girls may be modified in undesirable ways. McHugh (1992) recounts the story of the four year old girl who was watching her father play the game Wolfenstein 3-D. She loved animals, but when she saw that her father was going to be killed by a German Shepherd in the game, she screamed "Shoot all the doggies, shoot the doggies" (1992, p. 10)

Many of the games sold by computer shops could be described as adventure games. Addams (1990) has noted that before 1988, adventure games could be broadly described as puzzle-solving adventures, and role-play games. The puzzle-solving adventures could be further divided into text and graphic adventures. The text adventures were all text, as their name suggests, and the graphic adventures typically had a picture occupying most of the screen, with a space for a few lines of text underneath.

Allowing some time for research and publication, it could be assumed that much of the research on students and adventure games prior to 1989 concerned these types of games. It is not surprising that research on adventure games rarely highlights concern with gender bias, as the nature and availability of games altered significantly after most of the research was completed.

One advantage of such games was that they were often gender neutral. The game which was, arguably, the first computer adventure game ever written, was Adventure, written by Crowther and Woods (1976). This game commenced with the words, "you are standing at the end of a road before a small brick building". Whether "you" happened to be male or female was irrelevant, and such games could be played with little difficulty by boys and girls. It was true that some games had gender-stereotyped objectives; Transylvania asks the player to rescue Princess Sabrina, for example. However, changes in the industry altered the characteristics of the game. Infocom, which had been one of the most important producers of all-text adventures, sold out to Activision, and all-text adventures rapidly faded from the scene. Soon graphic adventures of the type described above had also mostly gone. In their place were icon-driven and animated adventures. Such games often required a more powerful computer, with a colour monitor and hard disk. More importantly, the player had to move a figure (which some in the industry call an EGO) to play the game. Clearly, the EGO, unless it was a non-human figure, had to be represented as male or female. Once such a decision was taken, it was logical for the advertising on the game package to be consistent with the gender chosen.

Although some writers have used commercial adventure games with their students (eg Russell, 1990 and 1991), it has become increasingly difficult to obtain recently produced games which are either gender-neutral, present women and girls in a positive way, or use a female as the EGO. Roberta Williams, who has produced the King's Quest Series, used a female EGO in King's Quest IV, - The Perils of Rosella. However, this was only one out of six games in the King's Quest series to date. The use of King's Quest IV with students has been described by Russell (1991), and by Salpeter (1992). The King's Quest Series are produced by Sierra-On-Line, who have also produced the Laura Bow series.

But beyond this list, it becomes difficult to name recent titles which would be likely to reinforce girls. The software shops which have been described earlier use as much of their available space as possible to display their titles. Out of what must be hundreds of game titles, it would be possible to count on the fingers of one hand those which might appeal to girls because they portrayed women and girls in a positive way. Very few games use a female character as the "Ego". As these games are purchased, it is highly likely that girls will see boys using them, and it will become apparent to them how girls are represented. It would not be surprising if some girls were to reach two conclusions:

1. Computer adventure games are not intended for girls.
2. Girls are not expected to use computers.

Callaghan (1992) has described research by Kay Fielden in which male and female students were asked to write stories about computers and/or technology. Fielden found that many boys wrote about war and violence, including computers killing each other and violent computer games, while girls wrote about computers breaking down, and their fear of technology. The violence which some boys associate with computers, and the insecurity which some girls see as being typical of their interaction with computers may be attributed, in part, to the software which is available for their use at home. While it is difficult to estimate the effect which the playing of games might have on the computer attitudes of boys and girl, they can, in effect, be considered as a powerful medium. Writers who discuss the effect of television on the attitudes and behaviour of students might find it useful to consider the potential power of computer games. It is interesting that McHugh (1992) cites research which found that, in the time of the Bush Administration in the USA, five out of ten children knew who George Bush was, but ten out of ten could identify Mario from the game Super Mario Brothers.

It is probable that the production of computer adventure games is market-driven. If more titles using girls in positive ways are purchased, then it is likely that similar titles will be produced and stocked. If parents make a conscious decision to purchase software such as The Perils of Rosella rather than Gunship 2000 or Commanche Maximum Overkill it may stimulate the production of a more useful range of titles. More importantly, a shift in the public's buying patterns may result, eventually, in a more positive attitude towards computers by girls, both at home and at school. Parents could influence this buying trend by guiding their children in their software purchases when they are young. Teachers could assist in this role by pointing out to parents the likely consequences if this duty were neglected.

An interesting indication is provided by Forsyth and Lancy (1989) that girls can enjoy computers as much as boys, and learn as much from them. While such findings only substantiate what many would believe to be true, it is nevertheless valuable to consider the writers' suggestion that the key to this situation is software. Computers used in this study did not feature traditional "male" approaches, including arcade action, explosions and battles. By using A.A Milne's Hundred Acre Wood, a fantasy game, girls were able to respond positively. Similarly, it could be argued that if parents are able to provide a computer and non-sexist software for girls at an early age, some later problems might be avoided or reduced.

3. COMPUTER GAMES IN AMUSEMENT ARCADES

The writer had the opportunity to research the participation rate of girls and boys both as players and onlookers in an amusement arcade which provided computer arcade games. Over a period of three weeks, it was apparent that the majority of players and onlookers were male. On one occasion, there were sixty-two persons in the arcade, and every machine was in use. However, only five girls were included in this number. Three girls were playing games, one was watching, and one later turned out to be a member of staff. This is consistent with research in Australia and in the United States, cited by Clarke (1990, p. 54) which found low participation rates for girls in the use of Arcade Games

Computers are chameleons. Their nature and purpose changes according to the software with which they are used. Similarly, the perception of the computer's value to an individual student is likely to be affected by the uses to which it is put. Even before students reach the classroom and think about using computers, they will have learned attitudes to computers and computing which are culturally dependant. Socialisation is likely to occur, and factors such as the media, family, peer groups, and socio-economic status may well affect a student's learned behaviours. A student who has the opportunity to use computers at school will see computers represented in a number of different ways, including non-school contexts. This paper has discussed the use of computers in three non-school situations, and it can be argued that the representation of computers will influence the attitudes of male and female students towards them. Students can see other people using computers, and this may include peer group, family, or media personalities. The way in which computers are used conveys an implicit message. Such factors as "who uses the computers?" and "what are the computers used for?" are likely to be critical determinants of girls' attitudes in an educational context. It is only when we start to critically reflect on the images of computing which bombard students every day that we can begin to understand how their attitudes are formed.

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COMPUTER EDUCATION OR PEOPLE EDUCATION?

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Someone once remarked to me that 'computer communication' makes as much sense as suggesting that we can 'communicate with a bus'. A computer can be a tool to assist people in communication, but it is not the object we communicate with. In a similar fashion, the term 'computer education' suggests that the computer is the object. In some fields, such as the development of expert systems and intelligent tutoring systems, this may be the case. However, in most instances, computer education reflects the use of computers in education or education about computers.

This may seem a trivial difference that is obvious to all, but I think that there can be a tendency in this field to concentrate on the technology rather than the education process. Another possible danger is to over-emphasise content. In either of these cases, we can easily neglect the reason we are in education in the first place ie. the students.

CONSIDER RESEARCH IN EDUCATION

Much research has been done to highlight the importance of considering students in effective teaching. Unfortunately, the demands of keeping up-to-date in a chosen field (particularly a rapidly evolving one such as computing) leave little time for searching out relevant research, reading it and considering ways of applying it.

Perhaps the last encounter with such research was studying for some education qualification. With luck, the lecturers were current in the field at the time, but nevertheless this could still be some time in the past. You may ask 'Why doesn't someone synthesise the results of current research into an easily digestible format?'. The fact is that many people do. There are numerous authors who write books on such topics as 'Effective Teaching' who have done their homework and researched the research.

Needless to say they are of varying quality and all will have a different bias to project, but I would suggest that to search out and read one that is suitable to your circumstances every so often would be a valuable exercise. While it is vital to remain abreast of your subject area, if you are in the field of education you should also endeavour to remain current there as well.

THEORIES OF TEACHING AND LEARNING

The methods you choose for teaching and assessment will reflect your own theories of teaching and learning. For example, the same content would probably be treated very differently by someone who considers learning to be a quantitative increase in knowledge compared to someone who considers it to also involve the formation of relationships between concepts and to the relationship and application in the real world.

As with learning, theories of teaching are many and varied. Some see teaching as the transmission of information. Such a content-based approach is still widely held, particularly in universities. The emphasis is on what the teacher does to students. If there is a failure to learn, those holding to this theory usually place the blame squarely on the learner. Students are placed into categories of good or poor learners depending on performance. While there will be individual differences in learning, this ignores all of the other variables that may come into play.

For example, if a subject has a high failure rate the remedy would more likely be to increase the entrance mark rather than consider improving the quality of the teaching. Interestingly, computer technology is seen as attractive by those holding to this theory in that it will allow more information to be presented.

Another common theory of teaching is that teaching is organising student activity. A failure to learn will now be ascribed to external conditions as well as the individual students. Many staff development efforts are aimed at accommodating this theoretical perspective. Teachers are given better skills and taught improved teaching techniques. However, the focus is still on what teachers do to students.

A theory that focuses more on the students is that teaching is making learning possible. "Teaching involves finding out about students' misunderstandings, intervening to change them, and creating a context of learning which encourages students actively to engage with the subject matter" (Ramsden, 1992). Here the content and methods are driven by the students and their problems.

In many cases, educators know and would proclaim adherence to one theory yet for pragmatic reasons teach as though ascribing to another. Such a position can considerably diminish the enjoyment of teaching. While each of us may feel constrained by the system we work in, we should see the need to keep our principles intact as a challenge. Another easy mistake to make is to have objectives based on one theoretical perspective, presentation on another, and perhaps assessment yet another.

It is important to examine alternate theories and reflect on your own experience and expectations to arrive at a consistent framework to work in (Of course, being theoretical such a position is not static, but open to change based on new evidence).

EFFECTIVE TEACHING

To determine whether teaching has been effective can vary depending on the theoretical stance taken. Suppose, for example, a group of students mastered all of the concepts involved in a computing subject and passed all of the required exams, but none of them ever wanted to see a computer again, The teaching was certainly successful, but whether it was effective depends on your perspective of teaching.

Research has numerous findings concerning effective teaching. It is interesting to note that they correlate highly with student views. This is not surprising though when you consider that being non-experts receiving the instruction they are in a unique position to judge what is useful. There are no rules for effective teaching because all students are (thankfully) individual and the process is so complex.

There is no 'best' way of teaching "it is folly, however, to carry this truism beyond its proper territory and to suggest that there are no better or worse ways of teaching, no general attributes that distinguish good teaching from bad" (Ramsden, 1992). Based on his study of research in higher education, Ramsden proposes six key principles of effective teaching -

KEY PRINCIPLES OF EFFECTIVE TEACHING

1. INTEREST AND EXPLANATION

To learn requires effort, but this does not have to be unpleasant. Think of any task or hobby that you were particularly interested in. Chances are that you could spend hours learning new skills with little thought of time passing. Part of the job of a good teacher is to generate interest.

For a start, it is difficult for students to get enthusiastic about a subject which their teacher has lost enthusiasm for. If this is your situation then you may have to alter your circumstances to some degree (eg. re-write subjects, change presentation techniques, aim for better quality teaching).

Computing is often seen as an intrinsically motivating area to study. While this may be true for some students, it is important to remember that there will be others who feel exactly the opposite, particularly if the unit is compulsory.

Using different methods of presentation will not only help to cater for different learning styles within a group, but can engender interest, particularly if chosen with this aim in mind.

Much can be gained by highlighting the relevance of the subject to students. In some cases, this can be general (eg. if you can use a word processor then the presentation of your assignments in all subjects can be better), but is particularly effective if it relates specifically to the individuals needs. This obviously requires knowledge of the student.

One problem that may be encountered if the students actually like the subject is that colleagues may consider it to be a 'soft-option'. (In a similar fashion, I know people who ,through some interesting shift of logic, consider Macintosh computers to be 'toys' for the fact that they are easy to use). While it may seem obvious to you, you may have to defend the position that learning can (and should?) be fun.

2. CONCERN AND RESPECT FOR STUDENTS AND STUDENT LEARNING

I have experienced courses conducted by aloof experts who gave the impression that they are the keepers of some mysterious knowledge. They make subjects appear harder that they really are. For example, during the first lecture of a second-year biology course we were told 'look at the person sitting next to you. One of you is going to fail'. This turned out to be far from the truth.

Research has indicated (and common-sense would dictate) that the opposite approach is better. Students should be encouraged to feel that the subject can be mastered. Opportunities should be given to allow students to succeed, particularly in the earlier stages of a subject. While not all students may eventually exhibit such mastery, more are likely to if they begin with the expectation that they can. Nevertheless, this should be linked with realistic expectations of the workload required to reach such mastery.

Associated with this is the availability of staff to students. This is a common problem in higher education and may reflect the much higher priority given to research compared to teaching. This situation is slowly changing, but even without external rewards, such as better promotion prospects, educators at all levels should be committed to high quality teaching.

3. APPROPRIATE ASSESSMENT AND FEEDBACK

No doubt, as a student, you experienced the annoying situation of receiving an assessment item back with nothing but a mark or grade on it. This is of absolutely NO use in locating errors in understanding or for establishing ways of correcting such errors. Feedback is really an extension of the commitment to be available to students. It takes time to give quality feedback, but I feel it is essential for effective teaching.

Much thought also has to be given to the assessment items themselves. Are they set with a view to highlight areas of understanding, or perhaps more importantly, misunderstanding, or are they simply a means to grade students? Do they individual parts of the items reflect the actual aims and objectives of the subject? It is easy to put together a test or assignment. It is much more difficult and time-consuming to put together a good test or good assignment.

4. CLEAR GOALS AND INTELLECTUAL CHALLENGE

At the very least, the teacher must be clear on the goals of a subject in order to plan appropriate instruction and assess performance. However, for students to gauge their own study and to get the 'big picture' it is important for them to be clear on the goals also. In computing, it is common to deal with trivial, irrelevant problems while the students gain the necessary skills to attempt more realistic problems. Without knowledge of where the subject is heading, students could easily question the relevance and lose interest.

In addition, "there is some evidence (Mager & McCann, 1961) that giving instructional objectives can markedly reduce the time required for learning" (Anderson & Faust, 1973). However, Schuell & Lee (1976) warn that simply providing the objectives does not guarantee their use and it is up to the teacher to clearly communicate such objectives.

Another problem that may arise is a lack of challenge and inflexibility. There should be scope for students to proceed beyond the set objectives if they are able and wish to do so. Many students in computing learn much by discovery and to stifle that could also cause students to lose interest.

5. INDEPENDENCE, CONTROL AND ACTIVE ENGAGEMENT

The long-term aim of good teachers is to make themselves redundant. The trend today is to view education as a life-long process rather than something bounded by several years in an institution. Ultimately, students should be self-disciplined and independent.

At all levels of education, there can be an emphasis on teacher-controlled activity rather than on gradually phasing over from teacher to student-control. This can be particularly distressing for a student when there is an abrupt change and suddenly they are 'on their own'.

A teacher-centered example is the typical science practical where students are given the precise method to follow. This neglects an important part of what real scientists do ie. design experiments. From my own experience, it is possible to get through nearly an entire science degree in this way. A student-centered approach is to give students appropriate equipment and initial conditions and ask them to design their own experiment to test a certain hypothesis. An added advantage is that afterwards students can compare designs and results.

Instruction in basic skills usually need to be provided in a teacher-centered fashion. Unfortunately, this is often where it ends. computing lessons need to be more than exercises in button-pressing. For example, in learning word processing a student may be able to follow the steps to use a different font for a heading, but do they know why they are using a different font, when to use a different font, which font(s) to use or how to go about locating the buttons to press if they were using a different package?

6. LEARNING FROM STUDENTS

None of the above provide rules which will work in all circumstances. Effective teaching "sees the relation between teaching and learning as problematic, uncertain and relative. Good teaching is open to change" (Ramsden, 1992).

All too often, evaluation stops at collecting data, giving it a cursory inspection and then forgetting about it. Real evaluation of teaching should consist of collecting evidence, analysing it and applying the results to modify further teaching. This may apply to an entire subject or parts of an individual lesson.

Collecting the data may be a formal process such as a student questionnaire or item analysis of a computer managed test. However, the easiest methods, which are often neglected due to time, are simply talking to the students and examining the products of their learning. Making time for these simple steps could make your teaching more effective and pleasurable for both you and your students.

SUMMARY

To be committed to high quality teaching in computer education (or any field), I suggest -

- Review current research on education (or other peoples reviews).
- Be clear as to your current theoretical basis for teaching and learning.
- Set clear goals and communicate them to your students.
- Don't be inflexible and allow room for challenge.
- Move students towards independent learning.
- Regularly evaluate your teaching and act on that evaluation.
- Where possible, make learning relevant and fun.
- Make time for:
  - consultation
  - developing appropriate assessment tasks
  - providing quality feedback
  - diagnosing student
  - providing quality feedback

- diagnosing student misunderstandings
- providing remediation

and STUDENTS!

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CHANGING CLASSROOMS - A NATIONAL PERSPECTIVE

A NATIONAL SURVEY ON THE INTEGRATION OF COMPUTERS INTO SCHOOLS: TEACHERS' CURRENT PRACTICES AND EXPERIENCES

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In 1992 a national survey of classroom teachers was undertaken to determine teachers' practice with computer technology. Drawing on the considerable knowledge base developed by teachers about the effective integration of technology into the curriculum the survey examines current and changing practice. The session will comment on those factors perceived by teachers to be barriers and incentives to the successful integration of computer technology into Australian classrooms.

INTRODUCTION

The last decade has witnessed unprecedented efforts by education authorities in Australia to ensure that schools are preparing students to meet the challenges and demands of the modern computer age. However, while large sums of money have been invested in hardware and, to a lesser extent, software, much less has been spent on reviewing curriculum policy and practice and developing teacher expertise.

Are teachers effectively integrating technology into their classroom organisations and teaching? If the answer is yes, what are their range of practices and what is their value? What barriers are experienced by teachers in the process of integrating technology into the curriculum? What are the incentives (both beliefs and experiences) which have encouraged teachers in their use of computers in the classroom?

To gain some measure of just what teachers do with computers in today's classrooms, the authors conducted a national survey in 1992 of teachers who had successfully integrated computer technology into their classroom. Using a survey instrument developed by the Centre for Technology in Education, Bank Street College of Education (who had conducted a similar survey in the United States in 1989), the survey set out to:

- identify teachers who had successfully integrated computer into their classrooms;
- describe their practice with the currently available technology;
- determine whether they believed their teaching had changed as a result of the use of computer technology;
- identify factors which may promote or hinder the effective integration of computer technology; and
- compare the results of the Australian study with those of the US.

Surveyed teachers were selected through contact with education authorities and professional bodies in all states. Self nominations were called for through publicity in various professional journals and conferences. Nominated teachers were considered to be experienced and effective users of computer technology in the classroom. They are, therefore, not representative of teachers in general. The study contains responses from teachers in all states, years P-12, a range of schools - state, parochial and independent - and from a range of communities. Of 731 teachers who were sent the survey, responses were received from 362.

This project was significant as it was only the second national survey undertaken on computer applications in Australian classrooms. The first survey, conducted in 1985, was commissioned by the Commonwealth Department of Education (as it then was) and examined the use of computers in learning programs, and the attitudes of students, teachers and parents to possible uses of computers to support the learning process (Fitzgerald, Hattie and Hughes, 1986).

In the last seven years, the technology itself has undergone considerable development. In addition, the number of computers in Australian schools has increased dramatically, as has the level of knowledge and expertise of teachers in relation to computer integration into the curriculum. This study enabled teachers to describe the most appropriate and effective ways by which they have acquired the necessary skills and knowledge required to effectively utilise technology in their curriculum.

Results from the survey highlight the need for organisational change, at the school level, central bureaucracy level, and in teacher education institutions. Professional associations do not appear to play a major part (as perceived by the survey respondents) in providing teachers with knowledge and/or expertise enabling them to become competent and confident users of technology.

WHO WERE THE SURVEY RESPONDENTS?

The teachers who answered the survey were a mature and experienced group, almost half (49%) between thirty-five and forty-four years old, and 61% having been teachers for thirteen years or more. Forty-five percent were women and fifty-five percent were men. The majority of teachers (59%) were from state schools, 33% from independent schools and 8% from parochial schools. The table below shows the number (%) of respondents from each state and territory. Further information on the school and teacher background is in Table 4 at the end of this paper.

QLD	NSW	TAS	VIC	SA	WA	NT	ACT
28%	10%	20%	18%	10%	10%	2%	2%

Table 1. Percentage of respondents by state

CHANGING CLASSROOMS

While the survey requested information on a wide range of issues related to the barriers and practices encountered by teachers in effectively using information technology, a key component was to determine whether the integration of the computer had made a difference to teaching methods and styles. It is this aspect which is discussed in this paper. As previously mentioned, significant sums of money have been invested by schools and education systems in providing computer hardware to support learning. It would seem, at least for the respondents to this survey, that this provision has had a positive impact. Of the teachers who replied to the survey, almost 76% felt that the computer had made a significant difference to the way they taught.

For these teachers, the advantages offered by computers to enhance their teaching was sufficient to overcome the problems and barriers which they also recorded in the survey. For them, the computer had been a major force in reshaping their curriculum and their own beliefs about teaching and learning.

From the data presented in Table 2, it can be seen that experience with using the computer has a positive influence on the effect teachers perceive on their teaching. Teachers who have used computers for an extended period of time in their classrooms, more frequently reported a difference in their teaching. It is interesting to note the jump in those replying in the negative at the 9-10 year period (See Table 2). While the survey has no way of determining specific reasons for this, it might be conjectured that this indicates a point reached by teachers where enthusiasm runs out for the incidental or occasional use of specific/favourite software, and real organisational change in their curriculum is required. Could this indicate a potential 'burn-out' point where teachers require assistance to refocus their use of computer technology?

No. of years using computers	Unsure	No	Yes
Less than 2 years	25.00%	21.43%	53.57%
3 to 4 years	16.39%	13.11%	70.49%
5 to 6 years	10.87%	13.04%	76.09%
7 to 8 years	11.36%	7.95%	80.68%
9 to 10 years	5.56%	14.81%	79.63%
More than 10 years	5.41%	10.81%	83.78%
TOTAL	**11.67%**	**12.50%**	**75.83%**

Table 2
Do you feel that integrating computers as an educational tool into the curricula you teach has made a real difference in how you teach? (n=360)

Many of those teachers who did not feel that computers had changed their teaching still acknowledged the worth of computers in the classroom. These teachers felt that their existing style of teaching was already suited to the integration of computer technology.

I do all this (reviewing students' work, working with small groups etc), but not as a result of using computers. Perhaps this is a reason for using computers. This is how I teach and teachers should teach; computers are incidental but do fit in ideally with good teaching practice.

The onset of computer technology hasn't changed how I teach, but has added another dimension to the classroom, an extra resource or tool, which the children can use, like they would a library resource.

There were also those who acknowledged that the computer had changed the way they taught but not in a positive fashion.

Wasted time due to computer maintenance - breakdowns and disk errors. It has become busier because you are always spending your own time reviewing software or fixing hardware problems. In effect, the teacher has become more of a technician.

The most significant change for these teachers has been the move from teacher-centred to student-centred classrooms. While other factors certainly contributed, they saw that effective use of the computer technology required them to change their style of teaching.

More comfortable with students working indendently	73.63%
Expect more from my students	72.16%
More time with individual students	66.30%
Better able tp present more complex material	54.21%
Tailor work to student's needs	53.48%
More comfortable with small group activities	51.65%
Less time lecturing to the whole class	50.55%
Less time with the whole class reviewing	32.60%

Table 3 How teaching has changed (N= 273)

Other technologies present in the classroom, such as video cassette recorders, overhead projectors and film projectors, do little to break down the traditional 'teacher-centred' model of the classroom. The computer too can also be used in this mode by delivering teacher-determined content to the students. However, the respondents to this survey clearly indicated that the computer played a significant role in changing the focus of their teaching from the teacher to the learner.

My teaching has become more student oriented. The main aim is for them to learn and for me to assist (or the computer or any other tool for that matter).

Main impact has been that I'm no longer a sage on the stage, but a guide on the side.

I realise that effective learning can go on without the teacher talking or directing. I have learnt to feel comfortable sitting in class for a lesson and not being asked a question while students get on with learning.

I no longer stand out the front thinking that I am a fountain of knowledge. Our classroom is based on a premise of collaborative small group learning. I am more of a facilitator but I'm still teaching/supporting children in areas of need.

The teachers' expectations of their students have increased with the use of computers. They expect more from them and believe that students can interact with more complex material using this new media. The computer is seen as an empowering device allowing students to accomplish tasks in ways not previously possible and to take greater responsibility for their own learning.

I am able (as are the students) to go far beyond existing curricula and work programs. I can provide more advanced instruction and have pleasure in teaching relevant topics.

My teaching has altered where I expect my students to take more responsibility for their learning. Students learn to work independently and to access other students for help. The teacher becomes a resource not a dictator.

As a teacher in Special Education, it offers a new perspective to some of the students who formerly had little or no skill in writing, numeracy, art or music. It offers a way of exploring information in a non-subjective format. The more severely disabled enjoy the sight, sound and animations, which they can control.

Mainly being able to give the students an idea, and then being able to let them go off and do the work. Also its great to see students often helping other students. I try to get the students to see the computer as a tool they can use, together with a little imagination, to produce work to a higher standard than they might otherwise be inclined to.

It has enabled my children to achieve things unheard of, and simply not possible, ten years ago.

I am expecting higher standards of work with the neatness, flexibility and power of the computer.

Use of the computer in my teaching has placed more of the responsibility for learning with the student, allowing them to progress at their own rate.

Teachers also believe that the computer enables them to meet the needs of individual students. Many teachers used small group activities to make the best use of limited computer resources thus enabling them to give increased attention to individual students.

More able to meet some special needs of certain children.

I'm more relaxed dealing with small groups/ individuals rather then whole class lectures. Different activities can now take place at the same time in the classroom.

Teaching is more individualised allowing greater help from remedial to talented. It is more flexible and enables one to explore 'unknown' areas and methods. Teacher is part of the process or team and not just an instructor.

Teaching is more individualised. Challenges presented are more stimulating and motivating for a wider variety of children.

My original teaching style might be called 'classic'. My lessons these days are less rigid and student based with an emphasis on individual instruction. My communication skills have improved as a result of the small groups and individuals with whom I communicate. These changes are a result of technology in the classroom.

Though I still value the basics of literacy and numeracy I spend less time on pen and paper drill activities and far more time in application situations (ie)
production of a newspaper, problem solving situations. I encourage individuality and creativity more and value kids helping and leading to a higher degree. Also I no longer feel that everyone needs to be doing the same thing at the same time.

What can also be read in these comments is a change in the teachers themselves. The beliefs and attitudes of the teachers is reflected through their responses to the open-ended questions of the survey.

My teaching has changed dramatically from when I started teaching back in 1956 (talk and chalk). Now children are able to work independently while I work with groups or encourage and direct. I love the computers and how children respond. I wish that I had been born 50 years later as I thrive on the type of teaching I am currently engaged in.

It has become more challenging and there is an excitement about me as I develop a theme or topic.

Computers enable me to create an exciting new teaching/learning environment in my classroom where individuality, creativity, problem solving and communication skills are highly valued.

Many of these teachers are obviously motivated learners, with an enthusiasm for their profession and a dedication to their students. They use a variety of software applications with the most common application being the word processor (96%). A significant number (89%) also make use of drill and practice software, 82% percent use adventure games, simulations and problem solving programs, 79% use the computer for keyboarding, while tutorial programs and paint programs are used by 78% of teachers.

While it is the tried and true applications such as word processors which are most commonly used many teachers indicated a willingness to use newer technologies such as multimedia, telecommunications and on-line databases; technologies which at present may be beyond their schools' current resources.

CONCLUSION

The picture that emerges from the responses to this key component of the national survey is one of dedicated teachers endeavouring to incorporate technology into their classrooms in ways that will enhance their teaching and students' learning. Many of these teachers have undertaken professional development in their own time, motivated by the beneficial changes they believe that computers have brought to their classrooms. This technology is, for them, a linking element which enables them to provide stimulating and effective learning experiences for their students and gives them more complete information about the level(s) at which individuals are performing.

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NOTES

Phil Buchanan was on secondment as a lecturer at Griffith University in 1992.

The authors wish to thank the teachers who participated in the survey.

Table 4 School and Teacher Background

1. Sex (n=362)	
Female	44.75%
Male	55.25%
2. Size of school (n=361)	
Large (1000+ students)	8.59%
Medium (500-1000)	27.98%
Small (<500)	63.43%
3. Year levels taught (n=362)	
Primary	57.73%
Junior Secondary	4.97%
Complete school	7.46%
High school	19.89%
Other	9.94%
4. Type of school (n=362)	
State	58.84%
Independent	32.60%
Parochial	8.56%
5. Ethnic group representation* (n=341) (as per respondents perceptions)	
Aborigine	2.61%
African	0.14%
Asian	3.96%
Other Australian	88.06%
Middle Eastern	1.54%
Other Groups	3.12%
6. Economic representation (n=320) (as per respondents perceptions)	
Very poor	8.25%
Working poor	23.79%
Middle class	51.13%
Relatively affluent	13.12%
Very affluent	3.86%
7. Size of town (n=361)	
Large city (100K+)	40.72%
Small city or town (<100 K)	27.98%
Rural town	15.51%
Rural district	11.63%
Other	4.16%
8. State (n=362)	
Queensland	28.45%
Tasmania	20.17%
Victoria	17.68%
New South Wales	10.22%
Western Australia	9.94%
South Australia	9.67%
Australian Capital Territory	2.21%
Northern Territory	1.66%

* Responses did not always add to 100%

IT IN SCIENCE EDUCATION - A CLOUDED VISION?

BY MAURICE TEBBUTT
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This paper is essentially in three parts. The first, in keeping with the theme of the conference, outlines my vision for IT within science education. The second part examines the actual situation at present, while the last part will suggest ways forward, and, as befits the practical nature of IT, will attempt to do so by demonstration with at least some degree of participation.

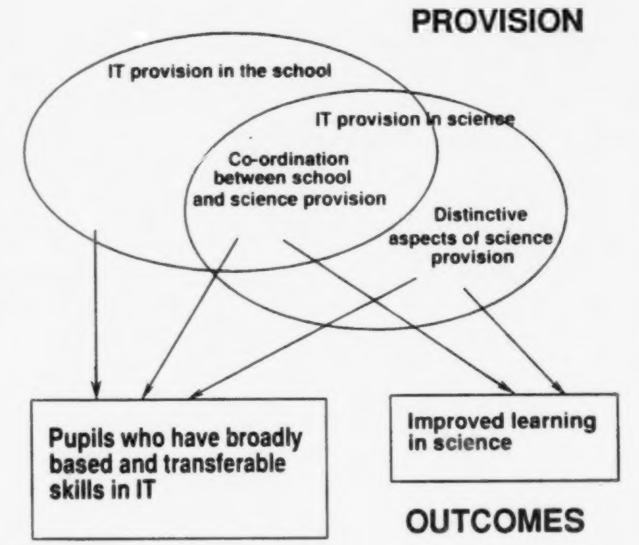

PROVISION
IT provision in the school
IT provision in science
Co-ordination between school and science provision
Distinctive aspects of science provision
Pupils who have broadly based and transferable skills in IT
Improved learning in science
OUTCOMES

Figure 1

Links between IT provision and outcomes

My vision for IT in science is at the same time both positive and easy to describe in general terms (Figure 1). The essential features of the provision of IT are;

a) the provision of IT in the school as a whole, and in science is substantial
b) these provisions are coordinated but
c) IT in science also makes its own distinctive contributions;

and there is mutual benefit in terms of outcomes, since

d) IT in science reinforces and supplements the work of the IT professionals in the development of skills which pupils must have in an increasingly technological world
e) and it is an aid to effective learning in science.

I, as a science educator, would not dream of suggesting for one minute that this is new to an audience which probably consists mainly of IT professionals. However, in the UK at least, it is the case that the IT coordinators in schools are relatively ignorant of those aspects of IT which are specific to science; and do not see it as part of their job to know which parts of science pro-

Figure 2

Contributions of various aspects of IT to general IT and science courses

IT contribution	Part of general IT course?	Part of science course?
Word processing or DTP	Yes	Yes
Spreadsheets	Yes	Yes
Databases	Yes	Yes
Drawing/painting packages	Yes	Yes?
CD ROM	Yes?	Yes?
Simulations	No	Yes
Interfacing (Datalogging, non-datalogging, control)	No	Yes
Hypermedia	No	Yes
Multimedia	No	Yes?
Games	No	Yes
Modelling	No	Yes
My World	No	Yes

vide appropriate uses for those general aspects of IT which can be applied to many curriculum areas. It is equally the case that science teachers do not see IT as a significant component of their work, and, for reasons which I will deal with later, perceive substantial barriers to its use in science. Because of this considerable degree of mutual incomprehension it is perhaps worth spelling out the contributions which science and IT can make to each other (Figure 2). The length of this list provides ample justification for my earlier assertion that the contribution of science to IT is both distinctive and substantial even allowing that some of the elements, like 'My World' or 'Games' are much more limited in their range of application than others, like spreadsheets. Figure 2 also indicates that the general work in IT in the school is capable of considerable reinforcement within science, and I hope to demonstrate later how IT can contribute to effective learning in science.

On the face of it, therefore, all the conditions seem to be satisfied for saying that my vision for IT in science should already be realised. However, it will be no surprise that, in the UK at least, the situation is far from the ideal. Thus, although there are computers in most secondary school science departments, and considerable amounts of computing in a few, the extent to which IT is actually used on average in this curriculum area is very limited. Figure 3 shows possible reasons for this, portrayed as falling into three groups to do with hardware, software and professional matters, but being somewhat difficult to describe since they are interrelated. Once again, some of this will be familiar to IT specialists, but some may not be since it is particular to other curriculum areas, such as science, and is important since each aspect contributes to barriers to the use of IT in science. Many of these barriers may seem to be individually quite trivial, but the combination of a number of barriers can often be sufficient to inhibit teachers whose interest in IT is limited from making use of the resource.

Figure 3

Barriers to the implementation of IT in science

Hardware aspects	Software aspects	Professional aspects
Shortage of computers	Complexity, power vs simplicity, ease of use	Lack of an IT culture Lack of knowledge of uses of IT in science
Organisation problems Dems vs pupil activity Science vs comp. lab base Fixed or mobile machines		Lack of expertise Lack of INSET IT not used in science
	Need for worked out ways of using general IT in science	Lack of coord. with school IT
Rapid development		Lack of policy for IT in school or science
Large variety of machines and capability	Non-portability of software	Widening gap between IT 'activists' and most science teachers
High tech. vs low tech. for interfacing		
Costs		Narrow focus for IT in the National Curriculum

Hardware is the most obvious problem. Few science departments have enough computers to involve all the pupils in a class at the same time. Therefore if computers are actually to be used in the science department ways have to be found to do this with the available hardware. One way would be to have a computer permanently mounted in each laboratory, which could then be used for demonstrations, or by groups of pupils as part of a circus of activities. Such an arrangement is not common, and although it is more generous than usual, it still has disadvantages. It precludes other staff from using the machine if the laboratory is in use, and prevents machines being gathered together in one laboratory so that pupils can use machines at the same time. A better solution would be for the computer to be mounted on a trolley so that it is capable of being easily moved and yet quickly set up once it is where it is to be used. It must also be said that an allocation of one system per laboratory on average is fairly uncommon, and these suggestions take no account of other practicalities, such as laboratories being sited on different floors, or even in different buildings! All of this has assumed that the computers are the usual 3-box types, which are both bulky and heavy, and whose associated cables represent a major problem to non-experts. However, who is to say what the future holds with the rapidly increasing power and availability of lap-top, notebook or palmtop computers? Although there are some experimental systems of such machines, they are probably not going to be generally available for some time, and even then will not be effectively used unless the classroom culture is beginning to be favourable.

A more realistic alternative, therefore, is for centralised facilities to be used by the science teachers whenever they are needed. Moving classes to such a facility is an extra demand, which can constitute a barrier to computer use, even if the facilities are available when they are needed. However, although many schools will have one or more computer rooms, the cost of these generally means that they tend to be timetabled for regular commitments and few schools can afford to have a computer room sufficiently free of commitments for departments to have flexible access to it. One school in the Birmingham area has been able to set up a computer room with 10 machines, for use solely by the science department, but this is very unusual, and is only possible for a very large school.

Clearly, cost is a major reason for the limited numbers of computers overall, and this is also one reason for different makes of computers being used in different parts of the school, because of the difficulty of equipping the whole school at one time. This problem is likely to continue because of the very rapid rate of development, which shows no signs of slowing down.

The variety of machines which are in use in a school at any one time might not be a problem if the software were portable between them. Unfortunately, educational software often tends to be produced for only one of the machines which are commonly used, and since the educational market is small it may not justify the labour of converting software to suit the remaining machines, even if the differences in the capability of the various machines would allow this. Whatever the reasons for the differences in machine provision, the consequent differences in software mean that it is less easy than it might be for skills which pupils develop in the general IT programme to be reinforced in other departments.

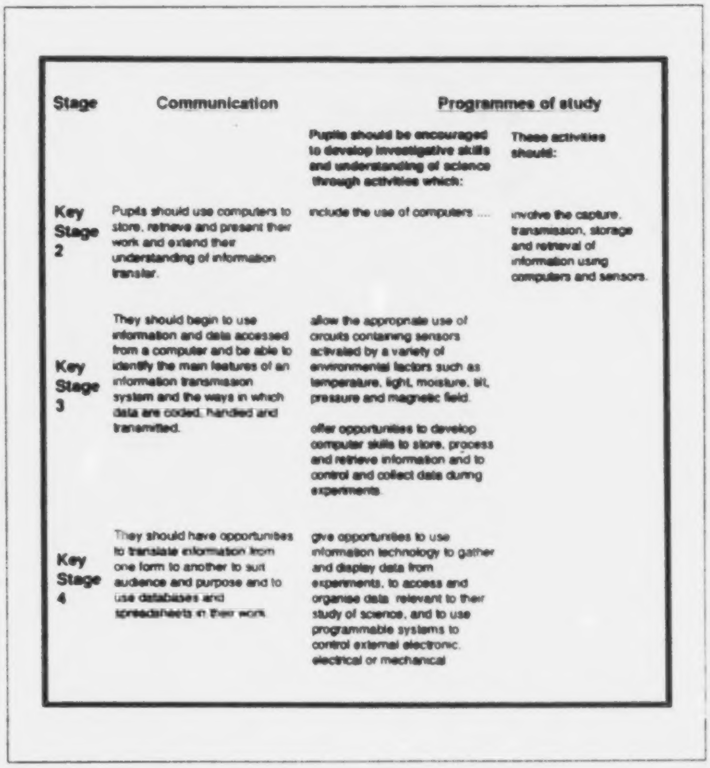
In addition to the barriers presented by hardware, and the associated software problems, the other major barrier to the use of IT in science concerns the teachers themselves, which is summarised in figure 3 as a lack of an 'IT culture' within science teaching. While it must be said that the situation has improved substantially over the last two or three years, it cannot be assumed that all the science teachers are sufficiently skilled to use computers at a personal level even in schools which have a good supply of computers. The usual level of competence seems to be the ability to use basic wordprocessing skills for their own use, but this does not seem to impinge on their lessons to any great extent. Those teachers who do not have even this basic level of expertise are quite unlikely to be prepared to use computers in their lessons. Many science teachers are also aware of the potential of datalogging in science lessons, but seem insufficiently persuaded to actually use these techniques in their lessons. Even those teachers who are sufficiently motivated to attend INSET courses on datalogging seem to be daunted by the combination of

a) the extra hardware needed for data logging (sensors, interfaces);
b) the software; let alone
c) the experiment itself!

Apart from datalogging, most science teachers would probably be unfamiliar with most of the applications of IT in science which have been described in figure 2. In contrast, there is a small, but increasing number who are very familiar with many of these aspects, and are innovative in their use. As development occurs at its usual pace in IT it is likely that the gap between the majority of science teachers and the 'activists' will increase, hence increasing the challenge presented by the need to close the gap.

Because most schools seem not to have an IT policy, or at least one which is known to anyone other than the IT specialists, it is not surprising that little is known generally about what knowledge and skills in IT are being developed in pupils. In these circumstances the lack of coordination with the basic work done in IT, and the lack of departmental IT policies is even less surprising.

Of course, all of this takes place within a socio-political context, which in the UK embodies a National Curriculum, which specifies the overall curriculum framework together with that for individual subject areas - in this case science on the one hand, and Technology, including information technology as a distinct and seperable component on the other. The references to the use of computers in science for pupils of secondary age are sufficiently clear and broad to encourage the use of IT



Stage	Communication	Programmes of study	
		Pupils should be encouraged to develop investigative skills and understanding of science through activities which:	**These activities should:**
Key Stage 2	Pupils should use computers to store, retrieve and present their work and extend their understanding of information transfer.	include the use of computers	involve the capture, transmission, storage and retrieval of information using computers and sensors.
Key Stage 3	They should begin to use information and data accessed from a computer and be able to identify the main features of an information transmission system and the ways in which data are coded, handled and transmitted.	allow the appropriate use of circuits containing sensors activated by a variety of environmental factors such as temperature, light, moisture, tilt, pressure and magnetic field. offer opportunities to develop computer skills to store, process and retrieve information and to control and collect data during experiments.	
Key Stage 4	They should have opportunities to translate information from one form to another to suit audience and purpose and to use databases and spreadsheets in their work.	give opportunities to use information technology to gather and display data from experiments, to access and organise data relevant to their study of science, and to use programmable systems to control external electronic, electrical or mechanical	

Figure 4
Extracts from the National Curriculum (Science)

(Figure 4), but it may be significant that all the references are from the general introductions, or the programmes of study (guidance for course construction), and there are no specific references in the statements of attainment (guidance for assessment)(DES, 1991).

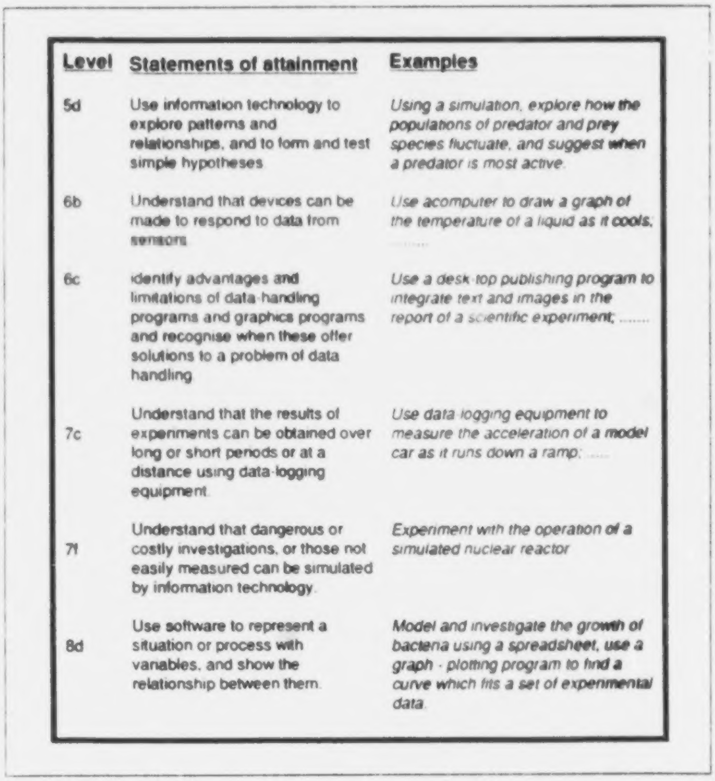
As might be expected the programmes of study and statements of attainment for IT itself are too extensive to reproduce here. While they clearly focus on core aspects of IT such as wordprocessing, spreadsheets, databases and presentational packages, they also provide examples drawn from science (and other curriculum areas) (figure 5)(DES, 1990).

While this might imply that a coordinated 'delivery system' was intended, or was at least desirable, instructions have recently been sent to schools which seem to require IT to appear as a clearly identifiable part of Technology (SEAC, 1993). Overall, therefore, there does not seem to be much 'Government encouragement' for science teachers to become involved in using IT, but the Department for Education has set up a working party on IT in science whose results should be available by now. It is to be hoped that some attempt will have been made to address the problem of the almost complete absence of INSET provision in this area. I regret that this appraisal of the actual situation in the UK is so much less heartening than the vision which I described initially, and I wonder how this compares with the situation in Australia.

I wish now to return to being more positive, making suggestions about what might be done to improve the situation, but tempering the original vision with the realism induced by the previous section.

However desirable it would be to have pupils' IT capability being developed

Figure 5
Links with Science in the IT National Curriculum

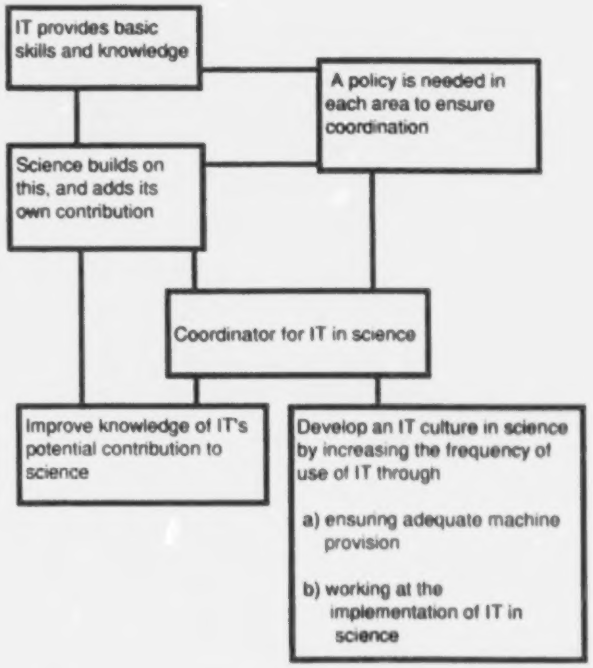


Level	Statements of attainment	Examples
5d	Use information technology to explore patterns and relationships, and to form and test simple hypotheses	*Using a simulation, explore how the populations of predator and prey species fluctuate, and suggest when a predator is most active.*
6b	Understand that devices can be made to respond to data from sensors	*Use acomputer to draw a graph of the temperature of a liquid as it cools; ....*
6c	identify advantages and limitations of data-handling programs and graphics programs and recognise when these offer solutions to a problem of data handling	*Use a desk-top publishing program to integrate text and images in the report of a scientific experiment; ....*
7c	Understand that the results of experiments can be obtained over long or short periods or at a distance using data-logging equipment.	*Use data logging equipment to measure the acceleration of a model car as it runs down a ramp; .....*
7f	Understand that dangerous or costly investigations, or those not easily measured can be simulated by information technology.	*Experiment with the operation of a simulated nuclear reactor*
8d	Use software to represent a situation or process with variables, and show the relationship between them.	*Model and investigate the growth of bacteria using a spreadsheet, use a graph - plotting program to find a curve which fits a set of experimental data.*

by means of a programme taught by both IT specialists and science teachers, it is unlikely to be realistic to expect many science teachers to contribute to general IT capability. Rather, science teachers would be expected to use IT as a means of improving learning in science by building in a coordinated way on the work done by the IT specialists, but also adding components which are distinctive to science (Figure 6).

Figure 6

Making IT in science happen


IT provides basic skills and knowledge
A policy is needed in each area to ensure coordination
Science builds on this, and adds its own contribution
Coordinator for IT in science
Improve knowledge of IT's potential contribution to science
Develop an IT culture in science by increasing the frequency of use of IT through
a) ensuring adequate machine provision
b) working at the implementation of IT in science

There will therefore be a need for policies for IT in the school and science department which ensure that the two curriculum areas are mutually supportive. All of this will require liaison which most science teachers are not qualified to do, and which is an undue demand on IT specialists - I suggest, therefore that this should be a designated role for someone in the science department with the appropriate knowledge and interest. The essential requirement seems to me to build an IT culture within the science department in which there are so many opportunities to use IT, which are so obviously useful, that science teachers are encouraged to use IT so often that the initial unfamiliarity with computers is eliminated, and their new-found expertise is continually practised. This will require

a) an adequate supply of machines
b) an adequate supply of other hardware (eg for data logging)
c) a collection of software which can contribute to many aspects of the science curriculum
d) worked-out ways of using general IT facilities (eg wordprocessors, spreadsheets) in science lessons.

I have already dealt with a) above, but b) is an aspect of hardware provision which can cause substantial problems. The 'high-tech' approach uses dedicated dataloggers and can be easy since the logging process may be automatic, including auto-recognition of the sensor. However, although the analysis software can be very powerful, it can also be quite daunting, particularly for beginners. The other problem is that this approach is expensive, especially if enough loggers are bought for pupils to use in groups. Some datalogging apparatus can be easily made in schools, which makes it much easier to afford (Tebbutt, 1991). However, it is less obviously easy to use than the 'plug-and-go' systems, even if simple software is used to avoid inhibiting beginners.

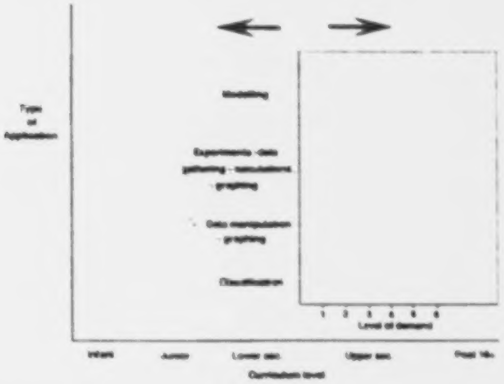
Datalogging is not the only context in which pupils can utilise interfacing. Suitable software enables pupils to practise reading a variety of laboratory instruments; to plot distance-time or speed-time graphs in real time; or to examine the process of coordination and the effects on motor coordination of substance abuse. The latter is one of the few examples of games which are available for science teaching. Another example uses an adventure game format to help pupils to learn about communications. The technique called 'cutting and sticking' is a popular way of helping pupils, particularly less able ones, to learn actively. 'My World' could be seen as an IT equivalent of this activity. Using databases can help pupils to develop useful skills, ranging from understanding or constructing simple keys to generating testable questions. Suitable software ranges from simple key-builders to powerful databases with substantial datafiles of scientific information. Even larger 'datafiles' of scientific information have recently become available on CD ROM, and these show signs of becoming very popular.

Hypermedia packages with ready-produced content, can be used in 'reception mode' by pupils, but currently few of these are available. Alternatively, such packages can be used in 'manipulation mode' as a means of helping pupils to learn by researching and constructing written, and illustrative material.

Wordprocessing and DTP can also enable pupils to experience the products of IT in reception mode and this is clearly the area in which most science teachers are best prepared. Pupils have much less opportunity to use these

Figure 7

A method of conceptualising spreadsheet difficulty



Level of demand

Lowest

1. Spreadsheet framework and data (and possibly formulae) are in the machine. Pupils merely use it by searching for patterns or plotting graphs.
2. Spreadsheet framework (and possibly formulae) in the machine. Pupils enter data and use the spreadsheet by searching for patterns or plotting graphs.
3. Spreadsheet framework and data are in the machine. Pupils enter formula(e) and use the spreadsheet by searching for patterns or plotting graphs.
4. Spreadsheet framework is in the machine. Pupils enter data and formula(e) and use the spreadsheet with guidance.
5. Pupils design the framework, enter data and formula(e) and use the spreadsheet with guidance.
6. Pupils design the framework, enter data and formula(e), and use the spreadsheet entirely on their own.

Highest

techniques in manipulation mode. Yet there are numerous situations when this would be possible, ranging from the routine writing up of experiments, to the production of notes on sections of a topic, such as the planets, or the electromagnetic spectrum, for subsequent conflation and distribution to the whole group. This process can often benefit from the draft, dialogue, redraft - via - editing process which is made so easy by wordprocessing. The IT coordinator in the science department should identify those aspects of the science curriculum which benefit from this approach. The same ideas can be applied in principle to the use of spreadsheets in science, but the process is arguably more difficult. Teachers are less used to spreadsheets, their use is very dependent on their content, and on the amount of help which pupils are given to set up the spreadsheet. A colleague and I have been trying to make a systematic approach to this problem (Tebbutt and Flavell) which conceptualises spreadsheets in terms of type, content level, and the degree of help given in completing the spreadsheet (Figure 7) (Tebbutt, 1993).

While this is based on a pragmatic rather than a theoretical approach, it does allow the work given to pupils at a particular stage to be differentiated according to their capability.

Helping teachers to overcome the initial barriers to computer use will still require a considerable amount of INSET, which, in the UK is tending to decrease in availability rather than increase. Trainee teachers are likely to be more computer literate than their established colleagues, and could act as change agents if their level of expertise was high. Unfortunately there are barriers to this too - teacher trainers tend to be no more expert than their colleagues in schools, and the pressures in the UK to make teacher education more school-based is likely to place the responsibility for training in IT in science in the hands of those who find it difficult!

I hope that I have been able to demonstrate my vision that IT has much to contribute potentially to learning science, and that there are many relatively simple means of doing this but that the vision is clouded by the existence of many barriers. I hope too that I have indicated how science teachers can be provided with an IT culture, which has benefits both for their effectiveness as science teachers, and their ease in using the technology; and therefore provides good prospects for 'blowing the clouds away'.

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HYPERTEXT AND LEARNER ACCEPTANCE OF CONTROL: LEARNING OUTCOMES OF HYPERTEXT USE.

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Hypertext is a term that is used to describe the concept of non-linear text. It is generally presented using electronic media that provide rapid response to readers when they nominate to branch to a different screen, or node of information.

As hypertext becomes increasingly available on microcomputers it seems inevitable that it will, as a consequence, be used more frequently in many contexts including the home and the classroom. Students will be exposed to a reading environment in which information is organised according to semantic links rather than organised into sequential pages and chapters. In order to use this opportunity effectively they will, as hypertext readers, be required to develop their general reading skills and confront the challenge of developing some new reading skills required by the media.

One vital new reading skill that hypertext readers must develop is the ability to navigate complex structures of information that possess many semantic links, rather than sequential page-by-page presentation. The study to follow explores a learner's willingness or ability to accept the challenge offered by non-linear presentation of information.

OVERVIEW OF HYPERTEXT RESEARCH

Well controlled experimental papers in the domain of hypertext are few and far between. Most papers written are reports about the experiences of those developing hypertext systems or anecdotal information about their effectiveness, as has been found by McKnight et.al. (1991):

> *To date researchers and developers have, in the main, been content to discuss the apparent advantages of hypertext systems for most tasks, occasionally describing systems they have implemented and informally presenting user reactions to them. Such reports are difficult to assess critically and it is easy to get carried away with the hype surrounding the new medium. If one looks at the proceedings of recent conferences on hypertext one will find that such reports are in the majority, with well-controlled experimental papers few and far between.*

Although there are not very many experimental findings, those that have been undertaken mostly address the successful use of particular aspects of the user interface, while a smaller number consider the benefits of sequential vs non-sequential presentation of material. Some findings regarding the use of interactive video and computer assisted instruction (CAI) have relevance due to the non-sequential form of presentation.

USER INTERFACE RESEARCH FINDINGS

Marchionini and Schneiderman (1988) are among those that address the issues related to the user interface in a summary paper of experimental findings. When considering the hardware aspects of a hypertext system, reference is made to a paper by Schneiderman that highlights two experiments that demonstrate a speed advantage in using the arrow keys to select hypertext keywords over the use of a mouse for the same purpose. Reference is also made to studies indicating that reading from cathode ray tubes (CRT) is up to thirty percent slower than reading the same material from paper.

Marchionini and Schneiderman also discuss the relative merits of the use of indexes over a browsing facility in hypertext environments. They describe their observations and studies of the 'Hyperties' system and the 'Grolier

Electronic Encyclopaedia' that indicate subjects directed to perform efficient searching for specific factual information predominantly chose to use an alphabetical index over the alternative strategy of browsing. In contrast however, they found that the study of a log of usage of a hypertext system in a museum setting revealed that the predominate usage was that of browsing. These findings indicate that the readers' purpose has a large bearing on the method of use of hypertext systems.

Hammond and Allinson (1988) also explore the usage of a hypertext system whose user interface is based on the holiday travel metaphor. In this system the user has the choice of guided tours, go-it-alone travel, orienteering or the use of an index facility. Hammond and Allinson found that the users of the system found it easy to use and felt that they were successful in achieving their aims. When studying the usage of the system, they found that the majority of users took advantage of each of the possible navigation methods, selecting the method according to the task to be achieved.

A study of the information seeking strategies of novices using an electronic encyclopaedia undertaken by Marchionini assesses the effectiveness of the user interface in assisting novices to achieve their reading goals. The subjects for the study were American elementary school students. The study found that the problems of cognitive overload encountered by students could be minimised by using the minimal capabilities of the system for tasks appropriate for the users. These minimal capabilities included the presentation of only single paragraphs of information on the screen at a time, simplified searching methods and a minimised requirement of keystrokes. Marchionini and Schneiderman conclude their paper by recommending key user interface design characteristics. They recommend; 'finding the correct information granularity for particular users, presenting interfaces with low cognitive load .... and striking a balance between analytical and browsing search strategies' (page 79).

Among those researchers exploring the advantages of particular user interface designs is Monk et.al. (1988). They explore the mechanisms of hypertext, scrolling and folding for browsing through computer programs. They conducted two experiments, finding that the most effective mechanism for users is scrolling, the second is folding and hypertext is the least effective. In a second experiment they report that providing a map of the hypertext structure improved the performance of hypertext users by twenty-five percent, making the hypertext equally as effective as the scrolling mechanism.

A study in which it was found that students make full use of the interactive, non-sequential nature of the interactive video system is enthusiastically described by Laurillard (1984). She found that the subjects of her study, twenty-two summer school first year technology students, enjoyed using the system and were highly motivated in its use. Laurillard admits however that the conclusions can only be made tentatively 'given the small numbers involved', and also, the majority of her findings are based on observational interpretations rather than empirical testing.

In contrast to the enthusiasm of Laurillard, Burwell (1991) questions the potential of the interactive video disk lessons to encourage learners to accept control of their learning. Burwell focused on field dependent learners, those learners who have difficulty extracting information in a perceptual or cognitive task and therefore take a passive approach, and field independent learners who have less difficulty in perceptual and cognitive tasks and therefore exhibit a more active approach to intellectual tasks. Contrary to expectations, Burwell found that in a visually rich environment, 'field dependent learners thrived on the personal control when aided with appropriate instructional advice'. He attributed this to the fact that, in a visually rich environment, field dependent learners spent more time on task. Overall, however, there was no significant difference in the post-test performance scores between the two groups.

Gray (1987) and Gay (1986) have also undertaken studies using non-sequential presentation of computer assisted instruction materials. They both suggest that the more apparent control a user has over computer assisted instruction the greater the learner's motivation. Gray and Gay also find that students who have an existing knowledge in the domain of the learning are more skilled at making selections of sequence. Specifically, Gay suggests that 'learners can be given more control if their prior understanding of a topic is relatively high; conversely, learners should be provided with more structure if their prior conceptual understanding of a topic is low'. Gay also suggests that learners should be taught how to use control options more effectively.

FINDINGS REGARDING SEQUENTIAL AND NON-SEQUENTIAL PRESENTATION OF INFORMATION

Gordon et. al. (1988) in their comparison of readers' use of hypertext and conventional linear text, also fail to share Laurillard's enthusiasm. Gordon et.al., contrary to their expectations, found that hypertext did not enhance expository or general interest reading. They concluded that hypertext techniques may be good for searching for information, but the difficulties presented by navigation make it difficult for a reader to concentrate on the content of a hypertext document. It should be noted however that in Gordon et.al.'s study, each reader was presented with two articles on different topics. The general interest group was presented with a sequential article and a non-sequential article, and another group read two technical articles presented in the two formats. The general interest readers were presented with the topics of 'Falling in Love' and 'Reverse Sterilisation', and the readers of technical articles were presented with 'Attentional Factors in Jet Aircraft Crashes', and 'Speech Synthesis and Recognition'. No direct assessment as to the effectiveness of the same topic presented in the different formats was attempted. The diversity of topics in the two presentation formats, and the degree to which the topics for general interest would actually be chosen by the subjects for general reading, raise some doubts about this study. A comparison of sequential and non-sequential presentations of the same reading material provides potential for research, and is the focus of the study described below.

INTRODUCTION TO THE STUDY AND THE HYPOTHESIS

This study focuses on the characteristic at the heart of hypertext, the non-linear presentation of information. It addresses the hypothesis that the non-linear presentation of material affects students' learning in two ways: firstly, that those students who experience the non-sequential branching achieve better results in a test of academic achievement than students who experience a sequential presentation of the same material; and secondly, that students who have the opportunity to utilise non-sequential branching within a computer based tutorial style lesson do use the opportunity, resulting in their gaining a better conceptual understanding of the information presented.

The method of presentation for the material used in this study was a HyperCard tutorial on the topic of the three database models, hierarchical, relation and network. A tutorial presentation was chosen rather than hypertext to isolate the non-sequential characteristic of hypertext from its other complexities.

Two different tutorials were created, both using the same screens of information and differing only in their introductory screens and method of presentation. Each tutorial has four main sections; one section that provides definitions of terminology used, and three sections that each provide a development of a database model with a summary of its features. The three database models are the relational, hierarchical and network models.

The sequential tutorial has 120 different screens of information and forces students to view screens in a pre-determined sequence. Students are allowed only two possible directions of movement from each screen: they can move to the next screen of information or to the previous screen. The sequence dictates that students read the definitions first, and then information about the relational, hierarchical and network models, in that order.

The non-sequential tutorial has 123 screens of information, the additional screens offering menu choices that allow material to be viewed in a user selected sequence. The first menu offers a choice of the four main sections, and within the sections on the models are additional menus which allow students to choose to see the development of the model or the summary of its features. The non-sequential version also offers a number of other branches that allowed relevant information in the three models to be linked. The three final screens from the model developments were linked, as is each section describing the database models' features. There is also a link from every screen to the definitions section and the main menu, and an option from every screen to more forward or back one screen. Students have a total of 30 unique branching opportunities in addition to the basic movements and the opportunity to branch to the terminology screen and the main menu.

SUBJECTS

The subjects for this pilot study were two groups of second year undergraduate tertiary students. Both groups were undertaking a semester course on databases, one group studying part-time and the other group studying full-time. A total of 32 students participated, 16 full-time and 16 part-time. Although the original groups were a little larger, some students were not present on the day of the tutorial, and others had problems with tutorial disks which made their data unusable.

METHODOLOGY

THE PROCEDURE

Students in each group were randomly allocated to undertake the sequential or non-sequential tutorial. For the purposes of this study they are considered as two groups experiencing either the sequential or non-sequential presentation. It is assumed that the random allocation removes the influence of the part-time or full-time study from the group comparisons.

Before introducing the tutorial on database models, it was necessary to establish whether the students had any existing knowledge of the topic. All students were undertaking this course for the first time and had little, or no previous experience in database use. As students had encountered the idea of drawing concept maps in other courses, they were asked at the beginning of their first lecture in the database course to draw a concept map of what they knew about databases. These concept maps indicated very little, if any knowledge in the domain and no evidence of any knowledge of the three database models.

Immediately prior to the tutorial they were again asked to draw a concept map of what they knew about databases, with specific instructions to include anything they knew about database models. It was indicated to the students that 'database models' was the focus of the tutorial they were about to undertake and it was not expected they would know about the topic, but to include in their map anything they did know. Again there was no evidence of any existing knowledge regarding database models.

Students were then each given a tutorial disk, written instructions on how to start the tutorial and a list describing the links that existed in their tutorial. Students individually worked through the tutorial with no time restrictions, with both groups, the sequential and non-sequential, working in the same room at the same time. Because the tutorial was done independently by students there was little, if any, interaction between students. Those who did begin to discuss any part of the tutorial were interrupted and asked to work individually.

THE MEASURES

Four measures were used in this pilot study. Three of these required students to complete written or 'tick box' answers to questions, and the other measure was a program trace recorded by the computer as students worked through the tutorial.

The three measures requiring written responses were the 'Short Answer Test - Database Models', the 'Test of Understanding of Database Models' and the 'Evaluation of the Database Models Tutorial'. Each of the four measures is detailed below.

1. A PROGRAM TRACE OF STUDENTS' PATHS THROUGH THE TUTORIAL

A potential of the computer tutorial environment was utilised in this study to record a trace of the students' movements through the tutorial. The trace kept track of the sequence in which the screens were viewed and the time spent on each screen. This trace made it possible to determine the time spent on task by each student, and the number of deviations from the linear made by students experiencing the non-sequential tutorial (students experiencing the sequential tutorial had no opportunity to deviate from the linear).

2. A SHORT ANSWER TEST ON DATABASE MODELS: IMMEDIATE AND DELAYED

The short answer test, with eight questions about database models, was designed to measure the academic achievement of the students. The questions required students to demonstrate specific knowledge and comprehension of information presented in the tutorial by providing written responses.

The short answer test was administered immediately after students had completed the tutorial, and again 10 weeks later. The delayed short answer test was administered in order to establish the degree of long term retention of the information. No time limit was imposed on students completing either test.

The short answer test was scored by allowing students one mark for each correct response per question. Students who gave more than one possible correct' response were rewarded with additional marks to a total of three marks per question, resulting in a total of 24 possible marks for the whole short answer test. After a list of acceptable answers was established, the test was marked by two independent markers. A correlation of .83 was found between the two markers.

In order to establish the reliability of the short answer tests, a reliability test was conducted using two scales. The tests indicated that question 6 contributed little to the scale, and on re-examination of the question itself it was apparent that the question was badly worded. As a result question 6 was omitted from further statistical analysis. The reliability of the first scale, the short answer test administered immediately after the tutorial was a co-efficient alpha of .48, and the second scale representing the delayed short answer test was .63.

3. A TEST OF UNDERSTANDING OF DATABASE MODELS

The Test of Understanding of Database Models was designed to measure the conceptual understanding students gained from the tutorial. It required students to construct a concept map from a given list of 10 concepts that were presented in the tutorial. At the time of designing this test an 'expert concept map' was developed by the tutorial creator, one which would hopefully be approximated by the students.

In order to measure the degree to which students developed a conceptual understanding of database models, a count of the number of links that matched the links in an expert's map was made for each student's concept map. A possible 12 links could be matched by the students.

4. AN EVALUATION OF THE DATABASE MODELS TUTORIAL

After completing the two other measures requiring written responses, students were asked to complete a questionnaire that asked them to give their opinions and provide evaluative judgements of the tutorial. Students were asked if the tutorial was easy to follow, worthwhile and whether they learned anything new. They were also asked a question about a preferred alternative learning style and a question which asked them to estimate the mental effort required by the tutorial.

The aim of this measure was to obtain evaluative information from the students, and to determine whether there was any correlation between students' performance and preferences.

RESULTS

Due to the exploratory nature of this study, and the small sample size, it was deemed appropriate to accept a significance level of 10 percent. Any discussion of the implications of these results is made with the realisation that these conclusions need to be substantiated in further studies with larger samples. Accepting these limitations to the findings, the results of this study point to some interesting implications for providing an environment in which students are able to control their learning through the selection of branches and are worthy of discussion.

PROGRAM TRACES

The program traces permitted the gathering of information on the time spent on task by each student, and the number of deviations from the linear made by each student. The measure of the number deviations from the linear is appropriate only to the group experiencing the non-sequential tutorial, as the group experiencing the sequential tutorial had no opportunity to deviate from the linear at all.

An observation from the program traces is that some students took the opportunity to re-enter the tutorial after having worked through it the first time. This was an unanticipated behaviour, and occurred when students were asked to complete the short answer test. When entering the tutorial for subsequent times, students who experienced the non-sequential tutorial went more directly to the information they required. Some students did reenter the sequential tutorial, but they were fewer than those who reentered the non-sequential tutorial. Those that did re-enter the sequential version laboriously worked through the whole sequence, spending more time on some screens, possibly while they completed written answers. One student who re-entered the sequential tutorial worked through the whole tutorial four times.

From the program trace it was possible to determine the number of deviations and time spent on task for the initial time working through the tutorial, and for subsequent uses of the tutorial. Statistical summary information is provided in Table 1.

Statistical results for time on task and number of deviations from the linear.

	Sequential			Non-Sequential		
	First	Subsequent	Total	First	Subsequent	Total
Time on Task (in minutes)						
Mean	31.3	9.9	41.2	42.2	16.7	58.9
Standard deviation	12.8	16.0	18.5	31.3	23.8	33.3
Range	20-69	0-40	20-69	13-110	0-70	13-110
Number of subjects	15	15	15	17	17	17
Number of deviations from the linear Mean	0*	0*	0*	2.1	2.3	4.4
Standard deviation	0	0	0	2.5	3.7	4.3
Range	0	0	0	0-11	0-10	0-11
Number of subjects	15	15	15	17	17	17

* Note that there was no opportunity to deviate in the sequential tutorial

From these statistics it is apparent that the students using the non-sequential tutorial did not use many of the branching opportunities available. With all the permutations of the possible 30 basic links, and the opportunity to branch from every screen to the definitions screen or main menu, the total number of deviations from the linear was an average of 4.4. When students reentered the tutorial the average number of deviations was greater (3.4) than the number of deviations on their first use of the tutorial (2.7). Those students who actually reentered the tutorial numbered seven in total, and the mean number of deviations for those students in their subsequent entries was 8.3. Although the number of deviations from the linear is generally low, students who reentered the tutorial accepted more opportunities to branch.

Mean time on task for the non-sequential group on their first time through the tutorial is slightly higher (42.2 minutes) than those using the sequential tutorial (31.3 minutes), but not significantly so (p=.22) Their subsequent mean time on task (16.7 minutes) was again slightly higher than the sequential group (9.9 minutes), but again, not at a significant level (p=.35). A oneway analysis of variance indicates that the total time on task is significantly greater for the non-sequential group than the sequential group (p=.09), see Table 2. Although it can not be claimed that the first nor subsequent time through the tutorial contribute significantly to the total time on task, the larger amount of the numerical difference in time spent on task appears to be attributable to the first time through the tutotial.

It is interesting to note that the seven students who reentered the tutorial spent an average 40.57 minutes, compared to five who reentered the sequential tutorial spending a mean of 29.6 minutes in subsequent use. It is apparent that when asked to complete a task, more students reentered the non-sequential tutorial, resulting in them spending more time on task overall than the sequential group.

SHORT ANSWER TEST ON DATABASE MODELS

A oneway analysis of variance was undertaken on the results of the short answer test in order to establish if there was any effect of the non-sequential tutorial on students' performance in the short answer test. Accepting the 10% level of significance, for both short answer tests there is no significant difference between the groups, either immediately after the tutorial presenta

Table 2
Oneway analysis of variance for time on task

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob
Between groups	1	2442.07	2442.07	3.00	.09
Within Groups	30	24415.93	813.84		
Total	31	26858.0			

	Sequential Presentation	Non-sequential Presentation
Test immediately after tutorial:	Number of correct responses	Number of correct responses
Mean	9.20	10.41
Standard deviation	3.41	2.91
Range (possible 21 marks)	4-15	4-16
Number of subjects	15	17
Test ten weeks after tutorial		
Mean	5.77	4.79
Standard deviation	2.98	2.56
Range (possible 21 marks)	1-10	2-9
Number of subjects	13	14

Table 3
Statistical results for the short answer test, immediately after tutorial and 10 weeks later

tion (p=.35) or 10 weeks later (p=.33). Table 3 shows summary statistics for both short answer tests. As the short answer test has a possible total of mark of 21 (with question 6 omitted), it is apparent that the overall performance of the students in the short answer test was low, with fewer than 50% correct on average on both occasions.

CONCEPT MAPS

Students were asked to draw concept maps in order to assess the degree to which they developed a better conceptual understanding of database models. The general statistical results for the number of links parallel to the expert's map is provided in Table 4.

In order to determine the significance of the number of mappings a oneway analysis of variance was undertaken for the two groups. The results of this test are provided in Table 5. This result shows that the number of matching links for the two groups is significantly greater (p < .10) for the non-sequential tutorial.

	Sequential Presentation	Non-sequential Presentation
Mapping of concept maps to expert map for (of a possible 12)	Number of links	Number of links
Mean	6.00	7.47
Standard deviation	2.45	2.03
Range of mappings	0-9	5-11
Number of subjects	15	17

Table 4
Statistical results for number of mappings of subject's concept map to expert map

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob
Between groups	1	17.25	17.23	3.44	.07
Within Groups	30	150.23	5.00		
Total	31	167.47			

Table 5
Oneway analysis of number of mappings of subjects' oncept

EVALUATION AND PREFERENCE SURVEY

The evaluation and preference survey revealed some interesting information about the students feelings towards the tutorials, but there were no correlations that indicated any relationships between their performance and preferences.

Generally speaking the students indicated that they enjoyed working through the tutorial, learnt something from the tutorial and found it worth the time spent. Both groups reported that they did not get lost while navigating the tutorial, but this could be due to the fact that the non-sequential group did not deviate very much from the inherent structures. When asked to indicate alternative methods for learning about database models, the majority indicated that if given an alternative to the tutorial they would prefer hands-on practical work using each of the database models (18). Overall, the students rated the tutorials as requiring a medium amount of cognitive effort.

DISCUSSION

The first hypothesis, that students who experience the non-sequential branching achieve better results in a test of academic achievement than students who experience a sequential presentation of the same material, is not supported by these results. On neither occasions was there a significant difference in the means between the sequential and non-sequential groups.

Students did not perform well on the short answer tests, as is evidenced by an average of less than less than 10.5 for the immediate test and 5.3 for the delayed test of a total possible 21 marks. Several factors could have contributed to this outcome. The discrepancy between the mean score levels and the maximum possible score of 21 could in part be attributed to the fact that the tests were marked so as to allow students who gave more than one possible answer to a question to be rewarded with additional marks. The majority of students however did not provide a number of alternative answers, rather being satisfied when they had found one acceptable answer. Questions were not phrased in a way that suggested that multiple responses should be provided. The low results could also be attributed to the fact that the content material is relatively complex and the overall time on task was insufficient to appreciate all the complexities of the subject. Of additional significance could be the fact that the reliability of the short answer test was found to be rather low.

The second hypothesis, that students who have the opportunity to utilise non-sequential branching within a computer based tutorial style lesson do use the opportunity, resulting in them gaining a better conceptual understanding of the information presented is partly supported. Students using the non-sequential tutorial developed concept maps that reflected a higher conceptual understanding than those using the sequential tutorial, which supports the latter part of the second hypothesis. An average of 4.4 deviations from the linear indicates that there was not a large acceptance of the opportunity to branch.

Although neither group of subjects achieved high results in the short answer test, the non-sequential group did achieve a higher level of conceptual understanding, as is indicated by a higher level of convergence of the number of links matching the expert concept map . This could be attributed to the fact that the non-sequential group spent more time on task overall (an average of 17.5 minutes more than the sequential group) and in some cases engaged in more focused learning. Observations of the program trace show that students who unexpectedly re-entered the tutorial when asked to complete the short answer test, used the tutorial differently when they had a task to complete. These students went to the desired information more directly. The purpose of reading appeared to influence the manner in which the tutorial was used, resulting in a more focused approach to finding information and more time spent on task. The design of the non-sequential tutorial may have been such that on the first time through students found the material organised in a logical sequence and were not encouraged by need to use branching opportunities. It is when their purpose for reading changed that their strategy changed.

Of particular interest is the finding that the number of deviations from the inherent linear presentation in the non-sequential tutorial is not very high, with students only deviating on average a total 4.4 times. In the conditions of this study, the majority of students who were given the opportunity, did not use the branching facility.

LIMITATIONS OF THE STUDY

The limited sample size in this study makes it difficult to make generalisations about the results, although the findings do raise some interesting issues. Further studies of this nature, which use more substantial sample sizes, are required to provide more conclusive results that indicate the presence or absence benefits of non-sequential branching opportunities for readers.

The low reliability of the short answer test, particularly that completed immediately after the tutorial, limits the possibilities of demonstrating a significant difference in the means of the sequential and non-sequential groups. Further studies need to improve the quality of the measures of academic achievement to enable a more conclusive outcome considering any effect of the different methods of presentation to be determined.

The reentry of the tutorial by some students is an aspect that warrants further attention. Analysis of the program traces indicate that students engaged in more focused learning when their purpose was to complete a short answer test. Although this is an unexpected outcome of the study, it is an aspect that suggests promising potential for providing students with a specific task to focus their learning, and hence increase their use of branching opportunities. Giving students a task to complete, rather than reading material without a specific purpose, may result in them making more effective use of hypertext potentials.

The way that students reentering the tutorial focussed their attention on the most relevant sections of the tutorial to complete the short answer test, suggests that familiarity with the tutorial may have assisted students to more successfully navigate the information space. Establishing a knowledge base in a domain of study, together with a familiarity of the medium of presentation, may result in more effective learning in an hypertext environment.

Subsequent studies should explore the effect of providing students with a task to complete when reading in an hypertext environment. Exploration of the potential of particular tasks to provide a focus for learning may result in some interesting and beneficial outcomes.

SUGGESTIONS FOR FURTHER RESEARCH

In an attempt to identify strategies for encouraging hypertext readers to accept the opportunites to branch, the following ideas are presented as areas for possible future research.

OFF-COMPUTER ACTIVITIES TO COMPLEMENT THE USE OF HYPERTEXT

From the study it is apparent that learners do not accept the branching opportunities that are available to them in a lesson that allows them to nominate the seqeuncing of presentation of material. It is apparent that students should be provided with some assistance in their use of hypertextual environments, and perhaps some lessons can be learned from existing practices in classrooms that utilise computers.

The use of computers in Australian schools is often complemented by involving students in off-computer activities that are related to the computer based activities occurring in the classroom. Because of limited computer facilities many teachers organise classes into small groups of three to five students, with only one or two groups working at the computer concurrently. Those students not working at the computer are actively engaged in related non-computer work such as strategy planning, research, report writing or other cross curriculum activities. Such off-computer activities are often seen by teachers as being essential to the effective use of computers in their classroom.

The above described approach is frequently used and has been successfully applied for a number of years. This approach has potential benefits for the classroom use of hypertext, if appropriate and effective complementary off-computer activities can be developed to support learners. For example, off-computer activities could involve preparing students in a topic of reading in order to facilitate their effective sequencing choices when using the hypertext. As identified by Gay (1986), Brown and Deloache (1978) and Steinberg (1977), students with a prior conceptual understanding are better able to make better sequencing decisions. Other off-computer activities could involve pairs or small groups of students in evaluation of the strategies they used for locating information in the hypertext and then planning their path(s) for their next on-computer opportunity. Print outs of the paths taken and maps of possible paths would assist this process.

The findings from the study also suggest the potential for another type of classroom support to help hypertext readers. The fact that students in the study seemed to engage in more focused use of the tutorial when they re-entered to complete the short answer test, suggests that worksheets may help to guide hypertext readers. Teacher planned activity worksheets may help students to make appropriate sequencing decisions in order to attain desired reading goals.

Productive research could be undertaken to determine whether off-computer activities and well-designed worksheets will enhance the effective use of hypertext systems.

ISSUES RELATED TO LEARNER-CONTROL RESEARCH

When trying to think of ways to encourage students to accept and use the opportunities to branch, the related area of student control may suggest relevant considerations. Research into factors which affect a student's acceptance of control of his/her own learning has been undertaken in different contexts using a variety of teaching/learning methods. Consideration of these factors, together with the findings of this study, may indicate some directions of further research that are of particular relevance to the use of hypertext.

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IMPLICATIONS OF THE STUDIES OF EXPERTS AND NOVICES FOR TEACHERS AND STUDENTS OF COMPUTER PROGRAMMING

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In recent years computer programming has been introduced to many of our schools as an activity that has accompanied the introduction of the study of computers and computing. Pressure from the community, students and teachers has reflected the view that computers are now a pervasive part of our societal infrastructure and therefore are an essential subject of study in our schools.

The study of computer programming, as opposed to the curriculum uses of computing, is one which has been introduced in many cases without a full awareness of the inherent complexity of the activity. Many students have experienced feelings of frustration and inadequacy because of their inability to succeed. The complexity of programming is acknowledged by Rogalski and Samurcay 1989, p170:

> Acquiring and developing knowledge about (computer) programming is a highly complex process. It involves a variety of cognitive activities, and mental representations related to program design, program understanding, modifying, debugging and documenting. Even at the computer literacy level, it requires construction of conceptual knowledge, and the structuring of basic operations (such as loops, conditional statements etc) into schemas and plans.

Apart from its inherent complexity, many factors have contributed to the problems associated with the teaching and learning of computer programming in schools. These include: the limited resources and access to these resources by students; differing abilities and intelligences of students; the differing amount of access by students to computers at home; the threat that programming can provide to an individual's self esteem and image; the lack of teacher training in the teaching of computer programming; and, the circumstances under which some teachers are required to teach programming (sometimes being directed to teach the subject by a supervisor) (Perkins et al. 1986, pp 37-38). Perkins et al. (1987, p155) also claim that programming is precision intensive. 'It calls for an extraordinary high degree of precision in order to obtain a relatively modest degree of success. Contrast a spelling test in which 90% of the words are spelled correctly to a computer program in which 90% of the statements are coded correctly.'

The undeveloped state of pedagogies (Husic et. al 1989, p570; Perkins et al. 1986, p37) and the degree of experimentation in teaching methods also contribute to students' difficulties in developing programming skills. An investigation of the studies on the development of expertise generally, and of expert and novice programmers serves to highlight practices that can help students to develop their programming skills, and hence contributes to the development of successful pedagogies for teaching computer programming.

This essay explores the studies on expertise, particularly studies on expert and novice computer programmers. The reason for the focus on expertise is that computer programming is considered a study in its own right. Teachers of programming are trying to assist students to develop programming expertise - assisting them to make the transition from novice to 'expert' programmers (as much as time will allow). This essay does not address the issue of whether computer programming should be taught to help the development of general problem solving skills. Generalisability of problem solving skills is a topic worthy of discussion in its own right and beyond the scope of this essay.

As an extension to the discussion of expertise, this essay considers papers that suggest instructional strategies for teaching computer programming. It discusses their implications for NSW secondary schools in the light of the findings on expertise in programming.

A starting point is to establish the general characteristics that all experts are considered to possess, before establishing exactly what computer programming is and characteristics specific to experts in this domain.

CHARACTERISTICS OF EXPERTISE

Studies of expertise began in the 1970s in many domains. Collectively these studies have contributed to the development of a robust and generalisable body of knowledge of the characteristics of expert knowledge and behaviour (Glaser 1988, cited in Chi, Glaser and Farr 1988, pxvii). Studies of expertise have included those in the domains of physics problem solving, mathematical problem solving, computer programming, chess playing, medicine (Perkins and Salomon 1989, p18), reading architectural plans, reading circuit diagrams, interpreting x-ray plates and the game of GO, taxi drivers' knowledge of routes (Chi, Glaser and Farr 1988, pxvii). These studies have highlighted characteristics of experts in their respective domains which are briefly summarised below.

EXPERTS EXCEL MAINLY IN THEIR OWN DOMAINS

There is little evidence to suggest that a person who is highly skilled in one domain can transfer the skill to another. An example of this is a study of non-domain experts (chemists) who solved political science problems like novices, describing the causes for the problem at a very concrete and specific level,. Domain experts attributed the causes for the problems at the more abstract causal categories (Voss and Post 1988, in Chi, Glaser and Farr 1988). An obvious reason for such excellence of experts in their domain is that they have a good deal of domain specific knowledge.

EXPERTS PERCEIVE LARGE MEANINGFUL PATTERNS IN THEIR DOMAIN

Many studies have highlighted the fact that experts in a domain are able to recall information as 'clusters' or 'chunks' of information. For example, chess players recall configurations of pieces on a board as representing particular strategic formations (Perkins and Salomon 1989, p18), and computer programmers recall programming statements in clusters that represent programming structures (McKiethen, Reitman, Reuter and Hirtle (1981, cited in Anderson 1985, p258). These special configurations or 'chunks' that experts think with are often referred to as 'schemata' (Perkins and Salomon 1989, p18)

EXPERTS ARE FASTER THAN NOVICES AT PERFORMING SKILLS IN THEIR OWN DOMAIN

Although studies have found that experts are slower than novices in the initial stages of problem solving, experts solve problems faster overall. There are two factors to which this can be attributed: one is that in simple tasks such as typing, experts have acquired automated skills from their many hours of practice; the other is that experts can often see a pattern, or combination of patterns that lead to a solution which trigger a predefined sequence of solution actions (Chi, Glaser and Farr 1988, pxvii).

EXPERTS HAVE SUPERIOR SHORT-TERM AND LONG-TERM MEMORY

Experts are able to recall recently presented material at a level that seems to exceed the limits of short-term memory. This is not because they have capacities that are beyond the scope of other humans, but because the organisation of portions into one item for memorisation allows resources for greater storage. Experts also seem to excel in in long-term recall. For example, in chess, it is not uncommon for chess masters to recognise plays from certain well-known games (Chi, Glaser and Farr 1988, pxvii).

EXPERTS SEE AND REPRESENT A PROBLEM IN THEIR DOMAIN AT A DEEPER

When developing a representation for a problem experts see and use deep structures, whereas novices use surface features of the problem statement. For example, in categorisation of physics problems, experts may categorise problems as 'an application of the Conservation Law of Energy', while novices may categorise problems as those 'containing blocks on an inclined plane' (Chi et. al 1982, p42). Similarly, in computer programming, novices may categorise problems according to the syntax of a specific programming language, while experts will think of the problem in terms of the programming constructs required to reach a solution eg looping or conditional ***branching*** (Anderson 1985, p256). Strategies used to solve the problems reflect these categorisations of problems.

EXPERTS SPEND A GREAT DEAL OF TIME ANALYSISING A PROBLEM QUALITATIVELY

Protocols show that, at the beginning of a problem solving episode, experts typically try to 'understand' a problem, whereas a novice will plunge immediately into an attempt to solve for an unknown. To build a qualitative analysis of a problem an expert will develop a mental representation of the problem from which they infer relations that can define the solution. Experts develop such solutions by 'working forward'.

EXPERTS HAVE SELF-MONITORING SKILLS

Experts seem to be more aware than novices of when they are making errors, why they fail to comprehend, and when they need to check their solutions. For example, the expert problem solver in Simon and Simon's study (1978, cited in Chi, Glaser and Farr 1988) would often check his answer, and the expert physics-problem solver in Larkin's study (1983, ibid) would often abandon solution attempts before carrying out the mathematical details.

EXPERTS DEVELOP THEIR SKILLS OVER A LENGTHY PERIOD OF TIME

Evidence suggests that expertise develops over a long period of time. It is estimated that chess grand masters take at least ten years to reach such a rank (Chi et al. 1982 p12), and that it takes at least 100 hours to reach even modest computer programming proficiency in their first programming language (Anderson 1985, p255). Simon, (cited in Mayer 1981, p138) estimates that a person requires 50,00 'chunks' of domain specific information to become an expert, which of course would be acquired over a lengthy period of time.

PROGRAMMING DEFINED

Programming is defined in the Oxford Reference Dictionary of Computing (1991, p363) as:

> In the broadest sense, all technical activities involved in the production of a program, including analysis of the requirements and all stages of design and implementation. In a much narrower sense it is the coding and testing of a program from some given design.

As mentioned in the introduction, programming is viewed as a complex skill. Merrienboer et al. (1992, p23) suggest that programming is a multidimensional, complex cognitive skill that involve several component skills. For this reason, while the above definition does define programming, it is also appropriate to consider programming from the perspective of the cognitive activities it involves.

Rogalski and Samurcay (1990, p160) present a schema for analysing the cognitive activities involved in programming tasks from 'a real-world problem to a runnable program text'. This schema is shown below, in Figure 1.

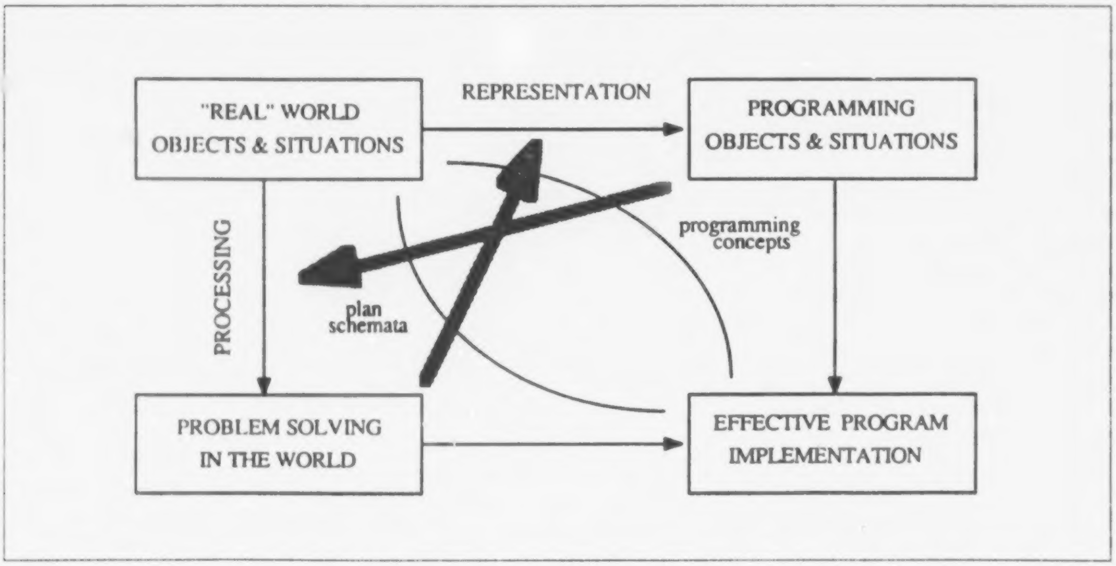


Figure 1. The task of programming, from Rogalski and Samurcay (1990, p160)

In this schema, the crucial dimensions in the activity of programming are processing and representation. There are two ways that individuals can move from a real world problem to program text that is implementable on a given device. A real world problem can be solved in the domain and then translated into program text. Or, alternatively, it can be approached in the programming language and then applied to the real world object. When problem solving takes place on a real world object, processing precedes representation.

An example which can be used to illustrate these ideas is that of sorting a set of names into alphabetical order (a relatively simple problem solving task). In the 'real world' situation above, the problem solver may take a set of cards with names on them, physically sort them, and then translate the procedure they have established into a program. I would suggest this is the way that novices are most likely to work, and how they are likely to be taught when introduced to programming.

In the 'programming language' approach the problem would be translated into a representation of data structures, for example an array, and then the procedures necessary to sort the data would be established. I suggest that in this situation expert behaviour would involve the activation of pre-defined part-solutions that, when combined, produce a solution to the whole problem.

CHARACTERISTICS OF EXPERTISE IN COMPUTER PROGRAMMING

Although the characteristics of expertise described above in the general section *Characteristics of Expertise* are indicative of the nature of expertise generally, there are some specific characteristics that expert computer programmers possess that should be specifically identified.

As described in the general section on expertise, differences have been found in the way in which experts and novices recognise and categorise problems. Novices categorise problems according to 'surface structures' of the problem, whereas experts categorise problems according to 'deep structures' (Chi et al. 1982, p42). Anderson (1985, p256) reports the development in experts of programming language independence. Novices tend to think of the solution to a programming problem in terms of the syntax of the language that they are using - which commands would be used to solve the problem. This leads to novices categorising problems according the surface features of the programming language in which the problem will be implemented. Experts however, go beyond the implementation language and think of a problem in terms of the programming construct(s) required to reach a solution, that is iteration (looping), selection(conditional branching) or sequence.

It is generally excepted that experts possess a large knowledge base in their domain, and that the organisation of the information is different to that of novices. In an attempt to determine how expert programmers organise their knowledge base, McKeithen, Reitman, Reuter and Hirtle (cited in Chi et al. 1982, p10) and Shneiderman (1976 , cited in Anderson 1985, p258) investigated the memory skills of computer programmers. This study paralleled the work of Simon and Chase (1973, cited in Perkins and Salomon 1989, p18) who conducted an experiment to determine the recall skills of chess masters (now recognised as a landmark study in the domain of expertise). The studies of programmers found that experts remember groups of instructions that represent structural components in programming, iteration for example. Even if they were not presented in any specific order, experts would group the instructions into structural components in order to remember them. Novices tended to remember instructions as individual components, or lines of code, and recall them much in the same order as they were presented in the memory test. The recall by novices and experts were similar in number, but the experts recalled a chunk of information to each statement the novice remembered. Experts remembered information in structural 'chunks', and with increasing skill more higher-order chunks are developed.

The chunks that are remembered by experts carry with them additional information that aid the solution of subsequent problems. Chi et al. (1982, p62) in a study of the chunks, or schemata used by experts, found that: 1) information remembered in a schemata activate higher level schemata; 2) expert's schemata contain additional procedural information, and; 3) expert's schemata contain much more explicit conditions of applicability to particular principles underlying a problem. As a result of the organisation of their knowledge bases and their previous experience in problem solving, experts do not require complex planning for simple problems. They have existing routines or 'production systems' that they can apply to a problem. Solving a problem becomes a case of categorising a problem into one or more problem types and applying existing routines (Chi et al. 1982, p19).

Exploration of the problem solving strategies of expert and novice computer programmers found a difference in the planning methods used. Both experts and novices attempted to solve a problem using the top-down approach, that is breaking a difficult problem into a series of smaller manageable problems, which are in turn broken into smaller even more manageable problems. The difference between novices and experts however is that experts tended to work breadth first, identifying all the sub-problems at each level before moving down to the subsequent level of sub-problems. Novices worked depth-first, breaking each sub-problem down to its smallest component before addressing the other sub-problems at the highest level. The top-down refinement of problems is a task that novices find difficult. They are aware that the approach of breaking down problems is appropriate, but do not know how or where to divide the problem into sub-problems. This could be attributed to their undeveloped knowledge base and undeveloped schemata.

The particular characteristics of expert programmers identified, that is: the development of language independence; the recall of programs as semantic structures rather than programming statements; the development of semantically organised schemata or 'chunks' of information; and the use of those schemata in the design of solutions to problems by top-down, breadth-first refinement; have relevance to the later discussion of teaching approaches that might encourage the development of expertise.

COMMON MISCONCEPTIONS OF NOVICE PROGRAMMERS

Having considered the characteristics of expertise and established the goals that novice programmers and their teachers strive to achieve, it is also important to consider the realities of the difficulties encountered by novice programmers. An understanding of the specific difficulties students encounter should provide an insight for teachers which may assist them to guide students.

Two groupings of errors have been identified by those investigating the problems of novice programmers. They are the identification of language independent conceptual problems (or 'bugs' in the jargon of the domain) and the language specific problems. Each of these groupings is discussed individually in the sections that follow.

LANGUAGE INDEPENDENT CONCEPTUAL BUGS

DuBoulay (1986, pp57-58) suggests that the difficulties in learning to program can be separated into five areas with a certain degree of overlap. The five areas begin with difficulty in *orientation*, the problem of finding out what programming is for, what kinds of problems can be tackled and what the advantages of programming might be. Secondly, there are difficulties associated with understanding the general properties of the machine they are learning to control, the *notional machine*. The third problem is associated with the *notation* of the language, mastering both the syntax and the underlying semantics. Forth, and associated with the problems with notation is the difficulties acquiring an understanding of the *structures* that can be used to achieve a goal. Finally there is the issue of mastering the *pragmatics* of programming, that is learning the skills of how to specify, develop, test and debug a program using whatever tools are available.

The conceptual problems of novice programmers are categorised differently by Pea (1986, pp27-32), who argues that there are three types of persistent conceptual bugs that novices must overcome. He refers to them as *parallelism, intentionality and egocentrism* bugs. Pea suggests that there is an underlying analogy that is at the root cause of these bugs, the analogy of 'conversing with humans'. Pea claims that many misconceptions in programming are caused by students' understandings of particular words or terms in common usage that have assumed somewhat different meanings in programming languages. Because the role of the 'listener' is changed in programming, the usual option of clarification for understanding is not available. The program interprets the language according to a specific mechanistic meaning. The three types of bugs are elaborated below with specific examples.

The parallelism bug in essence is the assumption that different lines of code in a program can be active or known by the program at the same time, or in parallel. An example of this is the IF statement. Students often believe that an IF statement will be implemented at any stage in a program when the condition becomes true, which is not the case in the implementation of a program but true in natural language. A parent suggesting "If you want to go to the store, I will drive you" is assumed to be an offer that lasts for more than the instant that it was made. The natural language meaning of an IF can be carried by the novice into the programming environment.

Intentionality bugs are those in which the student attributes goal directedness or foresightedness to a program, assuming that it goes beyond the specific instructions in the given code. For example, in the code below:

```
area = length * breadth
read length
read breadth
print area
```

the student assumes that the computer 'knows' the intention of the programmer and will know the sequence, as a person undertaking the same problem would. The knowledge that programs are implemented in the exact sequence they are written is not always accepted.

Egocentrism bugs are the flip side of intentionality bugs. Egocentrism is where students assume that there is more of their meaning for what they wish to accomplish in a program than what they actually present in the code. Students assume that the computer can follow the advice of the former Mayor of Chicago Richard Daley used to give reporters: 'Don't print what I say, print what I mean.' (Pea 1986, p30). An example of this is where students omit lines of code or variables, and assume the computer 'knows' or will 'fill-in' the gaps as a human listener would.

Rogalski and Samurcay (1990, pp162-165) and Mayer (1989, p132-147) also raise an overall conceptual problem that may be encountered by novice programmers, that of the conceptual representation of the computer device they are programming. They suggest that expert programmers refer to their knowledge of the system underlying the programming languages and the programming tools available. Novices who do not possess a good conceptual model of the computer they are programming make incorrect assumptions about the operations and mechanisms of the computer they are programming, reflected in the programming strategies they adopt.

STUDENTS' ERRORS IN SPECIFIC PROGRAMMING LANGUAGES

There are specific problems that students encounter with all programming languages, and there has been a relatively large amount of literature produced about these specifics (DuBoulay 1986, Sleeman et al. 1988, Putnam et al. 1989, and other references not listed for this essay). Presenting information of all material of specific errors in programming is beyond the scope of this essay, but a representative sample will be discussed specifically for errors encountered in using editors, operating systems and languages necessary for programming; some common errors in using the BASIC language and; some common errors using the Pascal language.

DuBoulay (1986, p60-63) identifies problems encountered by novices required to cope with operating system commands, program editors and the commands found in the programming language itself. Students loose track of exactly 'who' is being addressed and what are the appropriate commands to use. This problem is compounded by the situation in which a novice is introduced to all of these levels at the one time. A study of the problems encountered by novice high school Pascal programmers was undertaken by Sleeman et al. (1988). A sample of the most commonly made errors is provided here.

1. The alphabetic ordering of the variables determined the order in which data was read.
2. The statement WRITELN('Enter a number') caused a value to be read
3. WRITELN statements adjacent to a loop were considered to be part of the loop,
4. Assignment statements like a:=b were interpreted as swapping the values of the variables
5. Students believed that using a READLN statement with a meaningful variable name caused the program to select a value based on the name's meaning.

A similar study of the problems of novice high school BASIC programmers by Putnam (1989) with another collection of interesting findings. A sample of the problems encountered is as follows:

1. Students misinterpreted the use quotation marks in a PRINT statement such as PRINT "Q="; Q
   One student did not know what the quotes meant so just ignored them and said the value of the variable would be printed eg. 4
   Another student thought the value of Q would be printed in each case eg. 4:4
   A third student thought that the first value assigned to Q would be printed first, and the current value second eg. 0:4
2. Students believed that the READ statements would select the values from the DATA statements according to the meaning of the names. eg READ SMALLEST would select the smallest value in the data statements.
3. Students believed that the READ statements would cause more than one value to be assigned to a value eg READ EVEN would result in all the even numbers being assigned to the variable.

From the examples given in these samples of the findings of language specific errors, it is obvious that students make quite logical assumptions. These assumptions however can be quite beyond the imaginings of teachers who have established their own understandings of the mechanisms behind particular commands. Teachers who read these types of studies may be considerably enlightened, and be provided with an insight that may help them to overcome some of the problems that students encounter in learning programming.

The conceptual and specific misunderstandings of students, together with information regarding the characteristics of expert programmers can be incorporated into teaching approaches and strategies in the classroom.

INSTRUCTIONAL STRATEGIES IN TEACHING PROGRAMMING

A number of approaches to teaching computer programming have been used by teachers during the relatively short time that the subject has been taught, some heeding the lessons learned from studies of experts and novices, others not. The most common approach in the early years of teaching programming was the 'syntactic approach' which focused on the commands of a particular programming language. When it was obvious that the generalisability of such an approach was poor, a more semantic based approach was adopted, often referred to as the 'developmental approach' (Marchionini 1985). This is the approach that is advocated by the NSW Computing Studies Syllabus Years 11-12 for the programming core and option (evidenced by the list of suggested student experiences). An alternative approach that is now becoming common in the literature is a 'schema based approach' in which the schemata on which expertise are based are explicitly taught. Each of these are detailed in the sections that follow.

SYNTACTIC APPROACH

The syntactic approach focuses on the function of individual commands of a language and the specific syntactic construction of each command. Individual commands of a specific language are individually taught with explanations of their syntactic structure, their function and how they are commonly used. As students' knowledge develops they are encouraged to combine a number of commands for the purposes of solving a particular problem. In languages like BASIC the problems are typically mathematic type applications that require a temperature conversion or finding an average of a unknown number of values.

The syntactic approach could be described as operating at the level of novice programmers who have not yet developed the expert characteristics of having established a semantic understanding or schemata for particular procedures. Recognition is limited to the idiosyncrasies of a particular language.

While it is true that the syntax of a language must be mastered in order to achieve success in programming, an approach that focuses on the syntax of languages does not foster the skills that are characteristic of an expert. This approach does not assist the development of the recognition of deep structures of a problem, or the development of schemata of programming structures.

DEVELOPMENTAL APPROACH

The developmental approach as suggested by Marchionini (1985) does encourage the development of more expert-like skills than the syntactic approach. Marchionini builds his approach on the cognitive psychology and computer science work of Shneiderman (1980, cited in Marchionini 1985, p12). This approach focuses on the development of '...general concepts important for programming but which are independent of any specific language.' (Marchionini 1989, p12). A developmental approach to programming should:

1. Stress concepts rather than vocabulary and syntax.
2. Provide motivational, relevant examples and activities.
3. Proceed from the concrete to pictorial to abstract, according to the age and previous experience of the learners.
4. Use a sequence of increasingly complex activities which build upon and extend previously learned examples.

Marchionini also suggests the developmental sequence of programming activities to assist beginning programmers to develop expertise (shown in Table 1. below). This sequence includes ten types of activities, the most complex of them being to design and write a complete program. As children spend lots of time reading stories before writing stories of their own, novices programmers should also spend time reading and changing programs before being required to design and write a solution to a programming problem. Marchionini's activities are structured according to this philosophy. The ten types of programming activities are as follows:

	Activity Type	Example
1.	Use	enter, run, alter inputs
2.	Study	read, describe the purpose, trace execution, predict output
3.	Complete	supply missing statements
4.	Modify	add formats for output, comments, alter to produce related outputs
5.	Extend	add features - related output, files, generalise
6.	Test	try all cases, assume naive user role
7.	Debug	correct logic errors on-line and off-line
8.	Design	state problem; describe output, input and procedures; draw flow diagrams, draw screen display
9.	Code from design	code a given algorithm
10.	Develop	design and write a complete program

Table 1. - Devolpmental Sequence of Programming Activities from M archioni (1985, p. 14)

The developmental approach does not teach the syntax of a language specifically. In their activities of reading, using, changing and testing programs students will encounter the syntax of a language in their endeavours to understand existing programs. Commands are presented within the context of whole programming structures, rather than isolated syntactical items. Teachers need to draw students attention to the groups of commands that make up a programming construct and particular syntactic usages in order that students are explicitly made aware of the schemata they will use when undertaking more complex programming activities such as levels 8, 9 and 10 in the table above.

Marchionini's developmental approach requires more work on the part of a classroom teacher that the syntactic approach, but is more likely to result in skills that students can use with multiple programming languages. Students' knowledge is more likely to be at a level in which constructs of programming are recognised and used as 'chunks', a characteristic considered to be one of an expert programmers' repertoire.

A study undertaken by Merrienboer et al. (1992) provides evidence to support the use of the developmental approach over the syntactic approach. Merrienboer et al. investigated the effect of the developmental approach (referred to as a 'completion' approach) for the training of the complex cognitive skill of computer programming. They tested the effect of the completion approach over a syntactic approach (referred to as a 'conventional' approach) on low-level transfer and high-level transfer in a classroom situation and a Computer Based Training (CBT) environment. The completion strategy yielded transfer performance higher than or equal to the conventional training strategies in both the classroom and CBT environments. For high-transfer tests the completion strategy was significantly superior to the conventional approach for both environments. The diagram below (Figure 2) illustrates the results of this study.

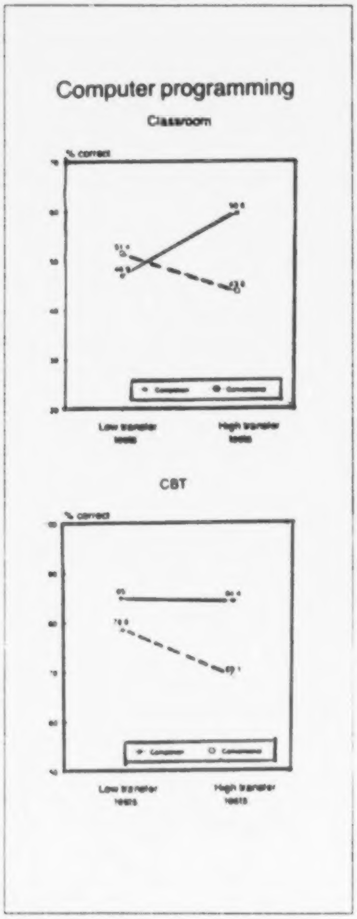


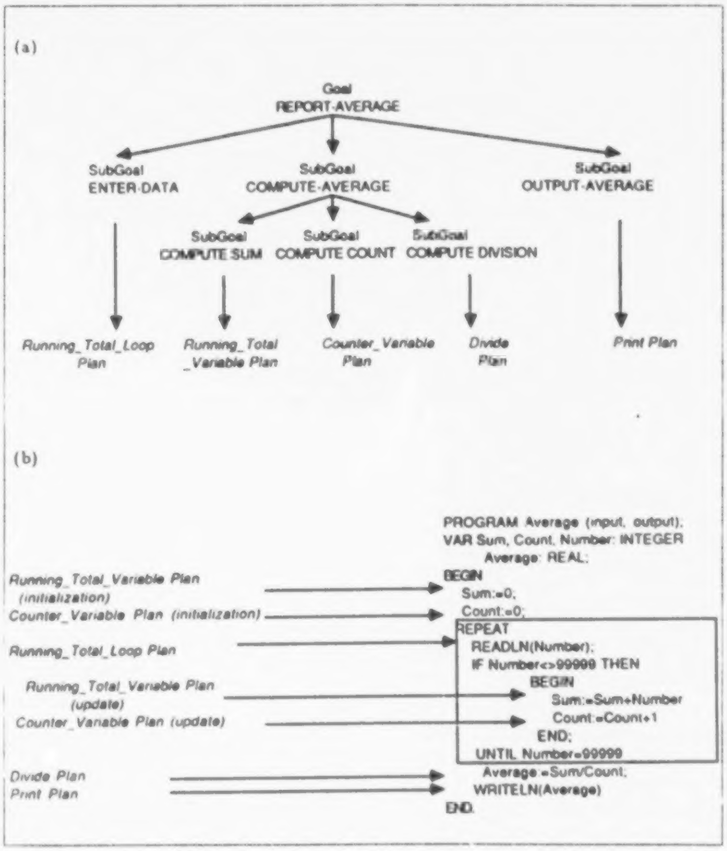
Figure 2. Scores on high- and low-transfer tests for the conventional and completion strategies in classroom and CBT environments.

SCHEMA BASED APPROACH

The schema based approach draws more directly from assumptions of experts' knowledge representations. In the schema based approach experts are assumed to use mainly knowledge structures that represent semantic information in the programming domain. These structures group together information on those parts of programs that perform the same function. The grouped knowledge structures, representing the schemata of experts, are explicitly presented to students in order that they learn to use them to solve programming problems.

In the schema based approach, a programming problem may be represented hierarchically as goals and subgoals with potential programming schemas associated with each goal or subgoal. An example of a problem broken into goals and subgoals is provided by Detienne (1990, p210) and shown in Figure 2. below. It illustrates the notion of goals and subgoals for a program that computes the average of a set of numbers. Goals are decomposed into sub-goals. At each terminal sub-goal in the tree there is an associated schema for the coding of that sub-goal into code, in this case Pascal.

Empirical support for the schema based approach can be found in studies of the knowledge organisation of experts. Shneiderman (1976, cited in Detienne 1990, p211) found that experts recall programs according to meaningful structures, and Adelson (1981, cited in Detienne 1990, p211) showed that the categorisation of programs or parts of programs is different according to expertise. Novices' categories depend on the surface features of a problem, while expert categorisation clusters around structural elements. The assumption on which this model is based, that experts possess schemata for categorising and solving problems, is supported by empirical research in this domain, and also in research undertaken in other domains (see the third, fifth and sixth general characteristic of expertise at the beginning of this essay). There is no apparent research specifically into the effect of using this approach.


(a)
Goal
REPORT-AVERAGE
SubGoal
ENTER-DATA
SubGoal
COMPUTE-AVERAGE
SubGoal
OUTPUT-AVERAGE
SubGoal
COMPUTE SUM
SubGoal
COMPUTE COUNT
SubGoal
COMPUTE DIVISION
Running_Total_Loop Plan
Running_Total _Variable Plan
Counter_Variable Plan
Divide Plan
Print Plan
(b)
Running_Total_Variable Plan (initialization)
Counter_Variable Plan (initialization)
Running_Total_Loop Plan
Running_Total_Variable Plan (update)
Counter_Variable Plan (update)
Divide Plan
Print Plan

```
PROGRAM Average (input, output);
VAR Sum, Count, Number: INTEGER
     Average: REAL;
BEGIN
  Sum:=0;
  Count:=0;
REPEAT
  READLN(Number);
  IF Number<>99999 THEN
          BEGIN
            Sum:=Sum+Number
            Count:=Count+1
          END;
  UNTIL Number=99999
   Average:=Sum/Count;
  WRITELN(Average)
END.
```

Figure 3. Representations of a program computing an average.
a) Hierarchical representations of goals and schemas.
b) Representations of combinations of schemas implemented in program code.

Perkins et al. (1986, p40) in discussing the schema based approach suggest that :

> ... skilled programming appear to depend on a repertoire of well-practiced schemas ... Such schemata and accompanying reasoning tactics might be taught to students directly, rather than leaving students to figure them out for themselves as more typically happens. ... There is every reason to think that these schema-based approaches to instruction will result in more efficient learning.

Unfortunately, the schema based approach is not used in classrooms very much, mainly because teachers have not been made aware of the approach and its potential. Some teachers who have become aware of this method at inservice courses I have attended are very keen to know more, but basically want a 'recipe' of how to use this approach. This is due in part I believe to the fact that teachers have had limited success with the methods they are using, but do not have the time required to undertake the necessary research and reading in order to explore the schema based approach fully and apply the method to all classroom programming activities.

CONCLUSION

Computer Programming is a complex activity requiring a high degree of problem solving skill and a high degree of precision. It is an activity that many students find difficult and unrewarding, but also an activity which highly motivates some students. It is an activity which has no established successful pedagogy, although teachers have been experimenting with a number of different approaches. These approaches include the syntactic approach, the development approach and smaller numbers of teachers are using the schema based approach.

Studies of the characteristics of experts in a domain, and specifically the domain of computer programming, have shed light on the strategies used by experts and the way in which experts develop their skills. Studies of the problems encountered by novice programmers have also shed light on the specific misconceptions and problems encountered by students of programming. Together, these two areas of study have provided teachers with valuable information to help them overcome some of the potential problems of novice programmers and provided an insight into the world of the expert programmer. This insight has contributed to a knowledge base of how people develop the skills required by programmers, and in the development of methodologies that allow teachers to assist students to develop even a modest level of expertise.

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GOVERNMENT SUPPORT OF COMPUTER EDUCATION IN SCHOOLS AND TEACHERS' CONFIDENCE IN THE USE OF COMPUTERS: A REPORT

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This paper reports on research conducted into the support of computer education activities in NSW government schools. The research compares the perceptions of the providers and the consumers of regional and state consultancy services during the introductory phase of this educational innovation.

The NSW Minister for Education released Computers in Schools: A General Policy Statement in August 1983. It's policy directions supported those of the Commonwealth Government at the time. The Department encourages teachers to see computers as having a role in schools in three ways:

- Learning about computers and computing
- Using computers for learning
- Using computers for management

COMPUTERS IN SCHOOLS - A GENERAL POLICY STATEMENT NSW DEPARTMENT OF EDUCATION (1983)

Some learning about computers occurs in the primary school through the use of the technology. But the majority of learning about computers, it is expected, will be learnt by students via study in the secondary area. This would be done through the undertaking of courses such as Computer Awareness (now incorporated in Design and Technology), Computing Studies 7-10 and/or Computing Studies 11 and 12 (or some other approved course of study).

The second major role computers have in schools relates to the value of the technology as a tool to assist the learning process. Teachers in primary schools and each of the secondary curriculum areas are encouraged to make use of computers in the teaching of the concepts of their respective curriculum statements/syllabi.

The use of computers by all teachers is affected by the quality of educational software that is available and the features of the computer being used. Some computer systems are better suited to curriculum tasks than others.

The third of the three areas for which computers are used in schools is the application of computers to the administrative roles within the school. To this end the Department has produced the Office Automation and School Information System (OASIS).

THE PURPOSE OF THE RESEARCH

The research was concerned with the support of computer education activities in NSW state schools. It covered aspects of support from departmental means (centre, regional and school-based) and non-departmental means (parents and community, commercial enterprises, professional association, tertiary institutions, etc.). However, the focus of the thesis was the relationship between differences in regional departmental support and responses made by teachers about their confidence in using computers in the school.

CONTEXT

The thesis focussed on the period 1986-88, the years immediately following

1986 to December 1988, regions attracted equal amounts of funding for the support of computer education despite these differences. Some regions, however, were able to attract additional funding to support computer education through other funding programs, such as the Disadvantaged Schools Program.

Table 3.1 provides a summary of the teaching population in each of the regions. (Source: Person to person contact with Departmental demographer in each region)

Table 1

Number of teachers in region

Region	Primary	Secondary	Total
Hunter	2158	2264	4422
North Coast	1877	1363	3240
North West	1041	1084	2125
Riverina	1120	1067	2187
South Coast	1875	1952	3827
Western	1271	1489	2760
Metropolitan North	2573	2906	5479
Metropolitan East	2076	3597	5673
Metropolitan South West	2744	2905	5649
Metropolitan West	3400	3200	6600

This indicates the larger teaching populations of the metropolitan regions. The region with the largest teaching population is Metropolitan West Region, the smallest North West Region.

Each of the country regions is geographically larger than any of the metropolitan regions. Western Region covers the largest geographic area, followed by Riverina Region.

Given the introduction of the microcomputer during the 1970's and its reduction in price in the 1980's, educators came to see applications for its use in schools. Some years after the first teachers began using these machines in schools (including the famed Canon Canola!), the Department saw a need to formulate appropriate policies for use of the technology in the state's schools. Coupled with this was the need to support those teachers currently using computers and, perhaps more importantly, seek out directions in which the technology could make a difference to the learning of children.

Table 2

Number of schools in region

Region	Primary	Central	High	Support	Total
Hunter	302	2	37	6	242
North Coast	219	6	26	3	254
North West	102	20	20	6	148
Riverina	145	14	25	7	191
South Coast	173	1	35	9	218
Western	130	39	40	6	215
Metropolitan North	166	0	48	24	238
Metropolitan East	177	1	61	34	273
Metropolitan South West	140	0	48	10	198
Metropolitan West	189	0	53	20	262

Source: Consultant's Major Questionnaire - Appendix 9 in thesis)

The employment of consultants was a logical consequence. These people could provide support, direction and linkage between resource people. Whilst early consultancy was limited, these people played a key role in the development of computer education in NSW schools. The first consultants with computer education as a part of their brief were Richard Wiktorowicz, Ted Duffy, Paul Jenner, Bob Baker, John Bennett, Paul Mulhearn and Trevor Kruger. Most of these people were employed as consultants for other curricula and perhaps only worked as consultants for part of the week but their work, during the mid 1970's, set trends for future consultancy.

Table 3

Geographic area of region (sq. km)

Region	Area
Hunter	30828
North Coast	35862
North West	143614
Riverina	155388
South Coast	53448
Western	369755
Metropolitan North	2817
Metropolitan East	664
Metropolitan South West	3564
Metropolitan West	5353

Metropolitan regions tend to have more schools, however, Hunter and North Coast Regions also have a large number of schools. (Source: NSW Department of Education, Annual Report, 1990)

SUMMARY OF REGIONAL DATA

The following table summarises a selection of the data recorded in the preceeding sections.

Consultants were there to support and train teachers, to initiate the production of support materials, and to provide advice relating to technology. As time passed more of these people became full time appointments, with the single (broad) brief - computer education. This began a significant period in which teachers received consultancy visits and publications related to computer education, participated in courses of various duration, and held school development days focussing on computer education (a relatively late innovation). Regions varied in the number of consultants employed, the types of service made available to schools and in how decisions were made regarding expenditure of computer education funds. These variations produced differences in the type and level of support available from each education region. As Fitzgerald, White and Woodley (1990) have shown, variations in the confidence levels of teachers were apparent.

Table 4

Summary of Regional Data

Region	5.1.1	5.1.8	5.2.1	5.1.2	5.1.3	5.1.4	5.1.5	5.1.6	5.1.7	5.1.9	Cleriel	Centre
Hunter	• •	• •	• •	• •	• •	• • •	• •	• •	•	• •	•	• • •
North Coast	• •	• •	•	• •	• •	•	•	• •	•	• •	•	•
North West	• • •	• • •	• •	• •	• •	• • •	• •	• • •	•	• •	• •	• • •
Riverina	• •	• •	•	•	•	• •	•	• •	•	•	• • •	• • •
South Coast	• •	• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •	•	• • •
Western	• •	• • •	•	• • •	• • •	• • •	• • •	• • •	• • •	• • •	•	•
Met. North	• •	• •	• •	• •	• •	•	• •	• •	•	• •	•	• • •
Met. East	•	• • •	• •	•	•	• •	• •	• • •	•	•	• • •	• • •
Met. Sth Wst	•	• •	• • •	•	•	• •	•	• •	•	•	• • •	• • •
Met.West	•	•	• •	•	•	• •	• •	•	• • •	•	• • •	• • •

Key: • = low/none • • = medium/part time • • • = high/full-time

Number of

5.1.1 Consultancy visits per teacher
5.1.8 Interactions per teacher
5.2.1 Consultants per school
5.1.2 Consultancy visits per school
5.1.3 All types of inservice course per school
5.1.4 School Development Days per school
5.1.5 After school courses per school
5.1.6 One day courses per school
5.1.7 Extended duration courses per school
5.1.9 Interactions per school
Clerical = employment of clerical assistance for computer education support at region
Centre = operation of regional computer centre

Table 1.5

Means: Primary and support school teachers' perceived number of hours of instruction time on computer education

The multivariate contrast comparing primary school teachers with support school teachers on the variable *perceived degree of professional development* was significant (mult. F = 8.33, $p < 0.01$, effect size 0.03). The univariate analysis clearly indicated that the variable contributing to this difference was *the number of hours of instruction time the teacher had had on computer education* ($p < 0.01$). (6.1.8)

Primary school teachers	Support school teachers
3.36	2.13

Table 1.6

Means: Primary and support school teachers frequency of use of computers at school and teachers' ability to preview a program for use in their class

The multivariate contrast comparing primary school teachers with support school teachers on the variable *perceived confidence in the use of a computer* was significant (mult. F = 2.40, $p < 0.05$, effect size 0.04). The univariate analysis clearly indicated that the variables contributing to this difference were *frequency of use of the computer at school* ($p < 0.01$) and the teachers' *perceived ability to preview a program for use in their class* ($p < 0.01$). (6.1.4)

	Primary school teachers	Support school teachers
frequency of use of a computer at school	3.32	4.20
ability to preview a program for use in their class	3.77	5.00

High school teachers indicated they had received more instruction time on computer education than central school teachers (Table 1.7), indicated they made greater use of in-school staff with computer expertise (Table 1.8) and they indicated greater confidence in the use of computers than central school teachers (Table 1.9).

Table 1.7

Means: Central and high school teachers' perceived number of hours of instruction time and extent of attendance at inservice courses on computer education

The multivariate contrast comparing central school teachers with high school teachers on the variable *perceived degree of professional development* was significant (mult. F = 3.46, $p < 0.05$, effect size 0.04). The univariate analysis indicated that the variables contributing to this difference were *the number of hours of instruction time the teacher had had on computer education* ($p < 0.05$) and *perceived extent of attendance at inservice courses in computer education* ($p < 0.05$). (6.1.11)

	Central school teachers	High school teachers
number of hours of instruction time on computer education	2.89	3.19
extent of attendance at inservice courses in computer education	1.91	2.14

Table 1.8

Means: Teachers' perceptions on their use of in-school computer-literate teaching staff

The multivariate contrast comparing central school teachers with high school teachers on the variable *use of Departmental support* was significant (mult. F = 2.38, $p < 0.05$, effect size 0.04). The univariate analysis indicated that the variable contributing to this differencewas *the use of the provision of teaching staff for their school with appropriate training and experience in computer applications* ($p < 0.05$). (6.1.19)

Central school teachers	High school teachers
1.92	2.20

Table 1.9

Means: Central and high school teachers' perceived expertise in use of an administrative program, of a database and of a spreadsheet

The multivariate contrast comparing central school with high school teachers on the variable *perceived confidence in the use of a computer* was significant (mult. F = 3.44, $p < 0.01$, effect size 0.06). The univariate analysis indicated that the variables contributing to this difference were *perceived expertise in the use of an administrative program* ($p < 0.01$), *perceived expertise in the use of a database* ($p < 0.05$) and *perceived expertise in the use of a spreadsheet* ($p < 0.05$).(6.1.6)

	Central school teachers	High school teachers
expertise in use of an administrative program	2.85	4.13
expertise in use of a database	3.67	4.14
expertise in use of a spreadsheet	2.58	3.37

Further general discussion of variations between metropolitan and country teachers, and teachers from various types of schools, can be found in the reports of Fitzgerald and Fitzgerald (1990), and Fitzgerald, Woodley and White (1990). Recommendations from these reports were used to develop the *Schools Renewal* strategy (1990) developed by Dr Brian Scott. Specific effects on teacher confidence, perception of the extent of their professional development and use of Departmental support possibly caused by the activities of regions can be found in the following sections.

DISCUSSION OF THE RESULTS OF THE MULTIVARIATE ANALYSES ON THE *INTERACTIONS* VARIABLE

The interactions variable was constructed based on information collected from regional consultants. The interactions variable considers the number of consultancy visits, school development days, one day inservice courses, after school courses and extended duration courses in which consultants and teachers were involved. Separate consideration is also given to any relationship between the number of consultancy visits and the number of school development days on teacher confidence, perception of professional development and use of Departmental support.

The purpose of the analyses conducted in this area was to identify consequences of variations in the number of consultancy visits, school development days and interactions in the broader sense on the confidence teachers have to use computers in their lessons, on their perceptions of the extent of their professional development and on their use of Departmental support.

The results indicated that the more consultancy visits and the more interactions with consultants teachers had, the more confident they felt to use administrative software (Tables 1.10, 1.11). It is possible the consultants had an effect on teachers' feeling of confidence in the use of some software. As teachers' rating of time with consultants increased, so did their rating of confidence in the use of these programs. The time with consultants included consultancy visits, one day inservice courses, after school courses, extended duration courses and school development days.

Table 1.10

Means: Teachers perceived expertise of use of a word processor and perceived expertise of use of an administrative program, by low/high consultancy visits

The multivariate contrast comparing teachers in regions receiving a low number of consultancy visits with teachers in regions receiving a high number of consultancy visits on the variable *perceived confidence in the use of a computer* (mult. F = 2.71, $p < 0.01$, effect size 0.05) was significant. The univariate analysis indicated that the variables contributing to this difference were *perceived expertise in the use of a word processor* ($p < 0.05$) and *perceived expertise in the use of an administrative program* ($p < 0.01$). (6.1.2)

	Number of consultancy visits	
	Low	High
expertise of use of a word processor	3.97	4.14
expertise of use of an administrative program	2.51	2.91

Table 1.11

Means: Teachers perceived expertise of use of a word processor and perceived expertise in the use of an administrative program, by low/high interactions with consultants

The multivariate contrast comparing teachers involved in a low total number of interactions with consultants with teachers involved in a high total number of interactions with consultants on the variable *perceived confidence in the use of a computer* was significant (mult. F = 2.71, $p < 0.01$, effect size 0.05). The univariate analysis indicated that the variables contributing to this difference were *perceived expertise in the use of a word processor* ($p < 0.05$) and *perceived expertise in the use of an administrative program* ($p < 0.01$). (6.1.3)

	Total number of interactions with consultants	
	Low	High
expertise in use of a word processor	3.97	4.14
expertise in use of an administrative program	2.51	2.91

The results indicated that with fewer consultancy visits (in fact altogether fewer interactions with consultants) teachers used the in-school computer-literate staff more (Tables 1.12, 1.13). However, (an exception was) the greater the number of school development days involving consultants the more teachers made use of in-school staff with computer expertise (Table 1.14).

Table 1.12

Means: Teachers' perceptions on their use of computer-literate teaching staff by low/high consultancy visits

The multivariate contrast comparing teachers receiving low numbers of consultancy visits with those receiving high number of visits on the variable *use of Departmental support* was significant (mult. $F = 3.10$, $p < 0.01$, effect size 0.05). The univariate analysis clearly indicated that the variable contributing to this difference was their *use of in-school teaching staff with appropriate training and experience in computer applications* ($p < 0.01$). (6.1.13)

Number of consultancy visits	
Low	High
2.19	1.92

Table 1.13

Means: Teachers' perceived use of the provision of teaching staff with appropriate training and expertise in computer applications by low/high interactions with consultants

The multivariate contrast comparing teachers involved in low total numbers of interactions with consultants with teachers involved in high total numbers of interactions with consultants on the variable *use of Departmental support* was significant (mult. $F = 3.10$, $p < 0.005$, effect size 0.05). The univariate analysis clearly indicated that the variable contributing to this difference was *the use of the provision of teaching staff with appropriate training and experience in computer applications* ($p < 0.001$). (6.1.16)

Number of interactions with consultants	
Low	High
2.19	1.92

Table 1.14

Means: Teachers' perceptions on their use of in-school computer-literate teaching staff by low/high number of school development days

The multivariate contrast comparing teachers participating in low numbers of school developments days involving computer education consultants and those participating in high numbers of school developments days involving computer education consultants on the variable *use of Departmental support* was significant (mult. $F = 1.96$, $p < 0.05$, effect size 0.03). The univariate analysis clearly indicated that the variable contributing to this difference was *the use of the provision of teaching staff for their school with appropriate training and experience in computer applications* ($p < 0.01$). (6.1.15)

Numbers of school development days involving computer education consultants	
Low	High
1.74	1.98

Staff seeking to learn more of computers have sought the expertise of in-school staff where consultancy assistance was not available. Following school development days (involving consultants), teaching staff made increased use of in-school computer-literate staff.

The number of interactions with consultants had no significant effect on the use of Departmental support. Teachers in regions rated high for number of interaction with consultants, did not rate any higher (or lower) for use of Departmental support than teachers in regions rated low for numbers of interactions with consultants.

Teachers made no greater use of inservice provisions nor called on the advice of regional or CEU staff following increased interactions with consultants. These results do not cover any increases in requests for use of publications which are reported in the section on the publications variable.

In summary, the more consultancy visits and the more interactions with consultants teachers had, the more confident they felt to use computers. With less interactions with consultants, teachers made greater use of the inschool computer-literate staff. Teachers made no more (or less) use of Departmental support as interactions with consultants increased.

DISCUSSION OF THE RESULTS OF THE MULTIVARIATE ANALYSES ON THE *CONSULTANCY* VARIABLE

While the earlier analyses sought to identify the relationships between the number of consultancy visits, school development days and courses and total number of interactions between consultants and teachers, this section specifically addresses the number of consultants employed by each region at any one time and any possible relationships. The consultancy variable is based on the greatest number of regional consultants employed at any one time in a region. It may have been that the earlier analyses, based simply on number of "formal" interactions, did not reveal the total effect of consultancy services to teachers. By simply addressing the number of consultants employed, general findings may have become apparent with further research conducted to find out what behaviours carried out by consultants may have been producing the effects.

However, the results indicated that the number of consultants employed by a region did not significantly effect teachers' confidence in the use of computers. There are a number of possible responses to these findings.

The findings may be explained by the fact that no regions employed enough consultants to make a significant difference to the results in this area. While it is true that some regions employed more consultants than others, it was the regions with the larger teaching populations that did this. Consequently, there was no significant impact on the confidence levels reported by teachers. So that, although South Coast and Metropolitan South West rated high for number of consultants employed, teachers from these regions indicated no greater feeling of confidence than those from the other regions. These results are particularly interesting given those results reported in the section on the interactions variable, where the greater the time spent with consultants the greater the feeling of confidence expressed by teaching staff.

It is possible that the effect of the work of these consultants may not yet have been felt. Teachers may require longer time to develop real feelings of confidence than time between support from these consultants and the time of responding to the questionnaire.

The results indicated that the greater the number of consultants employed by a region the greater the teachers' rating of the amount of instruction time and the extent of inservice education received (Table 2.1). This result indicates that as more consultants are employed, more inservice activities are provided to schools.

Table 2.1

Means: Teachers' estimation of hours of instruction time on computer education and estimation of the extent of inservice courses they have had in computer education by low/high number of consultants per school

The multivariate contrast comparing teachers in regions in the low band for number of consultants per school with teachers in regions in the high band for number of consultants per school on the variable *perceived degree of professional development* was significant (mult. $F = 3.80$, $p < 0.05$, effect size 0.02). The univariate analysis indicated that the variables contributing to this difference were *teachers' estimation of hours of instruction time on computer education* ($p < 0.05$) and *teachers' estimation of the extent of inservice courses they have had in computer education* ($p < 0.05$). (6.2.1)

	Number of consultants per school	
	Low	High
hours of instruction time on computer education	3.05	3.25
extent of inservice courses they have had in computer education	1.90	2.14

This result is reflected in both the results reported by the teachers and consultants from South Coast Region. For Metropolitan South West, the other region rated high for number of consultants, the number of one day courses only rated in the medium band; the number of consultancy visits, after school courses and extended duration courses rated low. The fact that Metropolitan South West is one of the regions with the greatest number of teachers to support, may have influenced these results.

The number of consultants employed by a region did not significantly effect teachers' use of Departmental support. Despite the fact that some regions employed greater numbers of consultants, teachers have reported no greater use of inservice provisions, advice from regional consultants or assistance from the CEU.

South Coast Region, rated high for number of consultants, also rated high for number of interactions with consultants (per school). Whereas Metropolitan South West Region (rated high for number of consultants), rated low for number of interactions.

In summary, employing more consultants may have only had an effect on the number of inservice activities provided to teachers. As the number of consultants employed increases, teachers perceptions of the extent of their professional development increases. No significant effect on teachers' confidence to use computers or on their use of Departmental support were recorded.

DISCUSSION OF RESULTS OF THE MULTIVARIATE ANALYSES ON THE CENTRE IN OPERATION VARIABLE

Analyses in this area sought to identify any effects related to the operation of a regional computer centre, the lending of software for evaluation and the employment of centre clerical assistants (ancillary staff). There were three simple variables formed from the data gained from the regional consultants. The computer centre variable indicated whether or not a computer centre operated, another variable addressed the number of software packages the region made available to teachers for trial, and the third variable indicated whether or not the region employed a clerical assistant to work in the computer centre.

Eight regions (all except North Coast and Western) elected to establish computer centres to base their support of computer education. The regions fell into four groups for number of software packages available to teachers for trial. They were labelled "low", "medium-low", "medium-high" and "high". Low and Medium-Low were grouped and Medium-High and High were grouped. Comparisons were made between regions rated low and high. For employment of clerical assistance regions were listed as "employing" (for full time and part time employees) or "not employing".

The operation of a computer centre did not significantly influence teacher confidence in the use of a computer, teachers' perceptions of their level of professional development or teachers' use of Departmental support. It could be suggested therefore, that the eight regions which have established computer centres have put time and effort into a resource which does not appear to yield significant benefits. It should be noted however, that the resources located in these centres are the same resources used in other areas of computer education support - areas which do show a significant relationship with teacher confidence. In establishing the centres the regions have simply made available these resources while not in use in other areas of support. It is also possible that the centres are having a significant effect on areas of support not covered by these analyses, or that as yet, the effect of the operation of the centres is yet to be registered. Given that most of the centres were established part way into this period of analysis, this may be relevant.

More than any other variable, the loaning of software to staff for trialling prior to purchase appears to have had a significant effect. With an effect size of > 0.50, teachers' confidence in the use of computers appears closely linked to the number of software programs available for trial from region (Table 3.1). In regions where a high number of software programs were available for trial (Hunter, North West, Riverina, Metropolitan South West and Metropolitan West) teachers were more frequent users of computers at school, felt more confident to use word processors, databases, spreadsheets and administrative software, felt more confident to evaluate software for classroom use and were more involved in computer activities at schools, than teachers in regions with fewer software programs available for trial.

Table 3.1

***Means:** Teachers' perceived use of computers at school, expertise in use of a word processor, administrative program, database, spreadsheet; ability to evaluate software, preview software, involvement in computer activities by low/high software available for trial*

The multivariate contrast comparing teachers in regions with access to a low number of software programs available for trialling with teachers in regions with a higher number of software programs on the variable *perceived confidence in the use of a computer* (mult. $F = 1510.20$, $p < 0.001$, effect size > 0.50) was significant. The univariate analysis indicated that the variables contributing to this difference were *frequency of use of computers at school* ($p < 0.001$), *perceived expertise in the use of a word processor* ($p < 0.001$), *administrative program* ($p < 0.001$), *database* ($p < 0.001$), *spreadsheet* ($p < 0.001$), *ability to evaluate programs* ($p < 0.001$) and *ability to preview a program for use in class* ($p < 0.001$). (6.3.1)

	Software available for trial	
	Low	High
use of computers at school	3.38	3.55
expertise in use of a word processor	3.98	4.30
expertise in use of an administrative program	2.98	2.99
expertise in use of a database	2.99	3.57
ability to evaluate software	2.94	3.06
expertise in use of a spreadsheet	2.38	2.53
preview software for use in class	3.51	3.91
involvement in computer activities at school	1.97	1.99

Teachers in regions with higher numbers of software programs available for trial also reported higher numbers of hours of instruction time and a greater extent of inservicing on computer education (Table 3.2). This may be due to teachers recording time spent on trialling software as professional development time, or it may be that in regions where higher numbers of software programs were available for trial, staff attended a greater number of inservice activities. While Hunter, North West, Riverina, Metropolitan South West and Metropolitan West regions reported high numbers of software packages available for trial, only North West rated high for number of interactions with consultants per teacher. Hunter and Riverina rated in the medium band and Metropolitan South West and Metropolitan West rated low for number of interactions with consultants per teacher.

Table 3.2

Means: Teachers' estimation of hours of instruction time on computer education and estimation of the extent of inservice courses they have had in computer education by low/high software available for trial

The multivariate contrast comparing teachers in regions with access to a low number of software programs available for trialling with teachers in regions with a higher number of software programs on the variable *perceived degree of professional development* was significant (mult. F = 291.92, $p < 0.001$, effect size 0.65). The univariate analysis indicated that the variables contributing to this difference were *teachers' estimation of hours of instruction time on computer education* ($p < 0.001$) and *teachers' estimation of the extent of inservice courses they have had in computer education* ($p < 0.001$). (6.3.2)

	Software available for trial	
	Low	High
hours of instruction time on computer education	3.03	3.22
extent of inservice courses they have had in computer education	1.95	2.45

Teachers in regions with higher numbers of software programs available for trial, indicated greater use of Departmental support (effect size 0.65). These teachers reported they made greater use of inservice provisions, specific curriculum advice from regional consultants, and involved regional consultants in more demonstration and team teaching lessons than teachers in regions where less software was available for trial. They made more frequent use of in-school computer-literate staff than colleagues in regions where less software was available for trial (Table 3.3).

Table 3.3

Means: Teachers' use of Departmental support by low/high software available for trial

The multivariate contrast comparing teachers in regions with access to a low number of software programs available for trialling with teachers in regions with a higher number of software programs on the variable *use of Departmental support* was significant (mult. F = 70.78, $p < 0.001$, effect size 0.65). The univariate analysis indicated that the variables contributing to this difference were *teachers' rating of the use of in general the provision of inservice education* ($p < 0.001$), *general advice and guidance from the Department's regional computer education consultant* ($p < 0.001$), *specific advice by the regional computer education consultant on the development of computer-related curriculum materials* ($p < 0.001$), *involvement of the regional computer education consultant in demonstration lessons or team teaching sessions showing the application of computers to the learning process* ($p < 0.001$), *software publications provided by the CEU* ($p < 0.001$), *software support from the CEU* ($p < 0.001$), *hardware support from the CEU* ($p < 0.001$) and *in-school computer-literate staff* ($p < 0.001$). (6.3.4)

	Software available for trial	
	Low	High
provision of inservice education	1.95	2.10
general advice from regional consultant	1.99	1.93
specific curriculum advice from regional consultant	1.73	1.87
regional consultant in dem. lessons or team teaching sessions	1.56	1.66
software publications from CEU	2.57	2.47
software support from CEU	1.96	1.94
hardware support from CEU	1.64	1.40
in-school computer-literate staff	1.84	2.03

It is of note, however, that these people made less use of general advice from regional consultants, software publications from the CEU, and software and hardware support from the CEU. It is possible that they have developed beyond the "general advice" stage and have a more developed understanding of the use of computers in schools. Their lower reported use of software evaluations may be due to the fact that they have worked out for themselves the merits of the software programs of interest to them. Lower demands on software and hardware advice from the CEU may be expected for similar reasons. It should also be noted that the CEU was intended to play a larger role in supporting the work of regions rather than providing direct support to schools.

The employment of centre ancillary staff appears to have had little effect on the confidence of teachers. However, country teachers reported a greater extent of professional development in regions where ancillary staff were employed in the computer education centre (Table 3.4). It may be that in these regions, the ancillary staff are contributing positively to the smooth operation of the region's computer education support. As a result, these regions are able to offer a greater number of inservice activities. North West region rated high for number of interactions between consultants and teachers; North West also employed ancillary staff in the computer centre. Riverina rated in the medium band for interactions between consultants and teachers. Riverina also employed ancillary staff. While Metropolitan East, Metropolitan West and Metropolitan South West all employed ancillary staff, they all rated low for interactions between teachers and consultants. Metropolitan teachers rated their extent of professional development lower generally, though it is interesting to note that the only metropolitan region which rated in the medium band for interactions between consultants and teachers (Metropolitan North) did not employ ancillary assistance.

Primary school teachers rated their use of Departmental support higher in regions where ancillary staff were employed in the computer centre. This may be due to these regions being able to ensure someone is able to answer the phones and provide direct contact and follow up while consultants have been out in schools. There was no specific direction implied by the results for high school teachers.

In summary, the results did not indicate any significant effects caused by the operation of a computer centre on teacher confidence, perception of extent of professional development or use of Departmental support. Teachers in regions where higher volumes of software was available for trial were more confident uses of computers, indicated a greater extent of professional development and reported greater use of more specific Departmental support.

Table 3.4

Means: Teachers' estimation of professional development in computer education by employment of centre ancillary staff

The multivariate effect involving the interaction between metropolitan and country teachers in regions with ancillary staff employed in the computer centre and teachers in regions with no ancillary staff employed in the computer centre on the dependent variable *perceived degree of professional development* was significant (mult. F = 3.54, $p < 0.05$, effect size 0.02). The univariate analysis indicated that the variables contributing to this difference were *teachers' estimation of hours of instruction time on computer education* ($p < 0.05$) and *teachers' estimation of the extent of inservice courses they have had in computer education* ($p < 0.05$). (6.3.3)

		Centre ancillary staff	
		Not employed	Employed
hours of instruction time on computer education	Metropolitan	3.53	3.22
	Country	3.11	3.33
extent of inservice courses they have had in computer education	Metropolitan	2.25	2.13
	Country	1.99	2.44

The employment of ancillary staff in centres had little effect on teacher confidence. Teachers in regions where ancillary staff were employed reported a greater extent of professional development. Primary school teachers rated their use of Departmental support higher in regions where ancillary were employed, but high school teachers rated their use of Departmental support lower in these regions.

DISCUSSION OF RESULTS OF THE MULTIVARIATE ANALYSES ON THE *PUBLICATIONS* VARIABLE

The purpose of this set of analyses was to identify any effects related to the number of publications produced by each region. The publications analyses were conducted using two "sub-variables". *Teacher confidence, perception of the extent of their professional development* and *use of Departmental support* were analysed with the *number of newsletters and journals produced by the region* and *the total number of publications produced by the region*. The variable based on *total number of publications* included newsletters, journals, user guides, teachers notes and the like. The regions varied in the number of publications produced. In the data they were grouped as "low", "medium" or "high" for number of publications produced. Regions rated "low" (North Coast, Riverina, South Coast, Metropolitan East) were compared with regions rated "high" (North West, Western).

The results indicated that variations in the number of newsletters and journals (in fact any type of publication) had no significant impact on the confidence of teachers. There are a number of ways in which this result could be interpreted. Broadly, the number of publications issued to teachers on computer education simply has no effect on their confidence levels. It is likely, however, that a number of other factors may have come into play. Producing the publications does not necessarily mean they have been read and used by teachers. Many consultants have reported a need to bring publications to the attention of teachers at school development days, inservice courses and meetings, despite the fact that the publications were already located within the school. The in-school flow of information could, perhaps, require review in some schools.

A well reported example by consultants was that of the CEU publications on software evaluation. While not specifically a regional publication, the case identifies a common problem. Teachers frequently report a desire to know more of the available educational software - what is available and how can it be used? The Computer Education Unit had produced large quantities of software evaluations and both regions and the CEU produced sample units of work or tips on classroom use for many packages. Most commonly, these publications were later "found" filed in the principal's office or in the computer coordinator's possession and not disseminated or broadly publicised amongst general teaching staff.

Another conclusion which can be drawn from these results is that there were too few publications produced to have any significant impact on confidence levels of teachers. Perhaps before any significant increase in teacher confidence is registered, a greater number of publications needs to be produced. The results from the survey of regions indicated one region with only three publications produced over the period, with thirty-one the greatest number produced by a region.

It is also possible, that despite the fact the publications were produced, and perhaps even read by staff, they may not have had the computers and related software to trial and hence develop confidence. Without the equipment to try out some of the recommended practices, teachers would be not much better off.

The publications themselves may not have been of sufficient quality to build confidence in the teachers. Teachers have frequently complained of the jargon involved when dealing with computers. Publications which used too much jargon or which failed to set out information in a readable fashion for the novice, may well have missed their mark in these early days of computer education.

Teachers rated their instruction time and extent of inservice education on computer education higher where regions produced more publications (Tables 4.1, 4.2). However, when further analyses are run it is seen that this is the case with high school teachers but not the case with primary teachers (Table 4.3). Primary teachers indicate more instruction time and a greater extent of inservice education when the number of publications produced is low.

Table 4.1

Means: Teachers' estimation of hours of instruction time on computer education and estimation of the extent of inservice courses they have had in computer education by low/high number of newsletters and journals produced

The multivariate contrast comparing teachers in regions in the low band for number of newsletters and journals produced with teachers in regions in the high band for number of newsletters and journals produced on the variable *perceived degree of professional development* was significant (mult. $F = 6.44$, $p < 0.005$, effect size 0.03). The univariate analysis clearly indicated that the variables contributing to this difference were *teachers' estimation of hours of instruction time on computer education* ($p < 0.005$) and *teachers' estimation of the extent of inservice courses they have had in computer education* ($p < 0.005$). (6.4.1)

	Number of newsletters and journals produced	
	Low	High
hours of instruction time on computer education	3.07	3.37
extent of inservice courses they have had in computer education	1.95	2.39

Table 4.2

Means: Teachers' estimation of hours of instruction time on computer education and teachers' estimation of the extent of inservice courses they have had in computer education

The multivariate contrast comparing teachers in regions in the low band for total number of publications produced with teachers in regions in the high band for total number of publications produced on the variable ***perceived degree of professional development*** was significant (mult. $F = 5.07$, $p < 0.01$, effect size 0.02). The univariate analysis clearly indicated that the variables contributing to this difference were ***teachers' estimation of hours of instruction time on computer education*** ($p < 0.01$) and ***teachers' estimation of the extent of inservice courses they have had in computer education*** ($p < 0.005$). (6.4.2)

	Number of publications produced	
	Low	High
hours of instruction time on computer education	3.07	3.30
extent of inservice courses they have had in computer education	1.95	1.92

Table 4.3

Means: Teachers' estimation of the extent of inservice courses they have had in computer education, by low/high publications

The multivariate effect involving the interaction between teachers in regions in the low versus high bands for *total number of publications* produced and *type of school* on the dependent variable *degree of professional development* was significant (mult. $F = 3.04$, $p < 0.05$, effect size 0.01). The univariate analysis indicated that the variable contributing to this difference was *teachers' estimation of the extent of inservice courses they have had in computer education* ($p < 0.05$). (6.4.3)

		Total number of publications produced	
		Low	High
extent of inservice courses in computer education	Primary	2.12	1.65
	High	1.68	2.11

The result for high school teachers may have been influenced by the use of publications at the inservice activities consultants attended. Through use of the publications at these activities, teachers would note the existence of the publications and the provision of inservice support. An excellent example of this is the pattern of inservice used by North West Region. Titled the RACE (Regional Awareness of Computer Education) Course, staff were stepped through a series of inservice modules on basic computer use in schools. The modules worked staff through a series of activities and drew attention to other useful publications.

When more publications are produced, teachers indicated they made greater use of inservice provisions and Departmental consultancy (Tables 4.4, 4.5). Once again however, further investigation shows that high school teachers make greater use of inservice provisions and Departmental consultancy when more publications are produced. Primary teachers make less use of inservice provisions and consultancy advice when more publications are produced (Table 4.6).

Table 4.4

Means: Use of inservice education, general and specific advice from the regional consultant, and involvement of the regional consultant in demonstration lessons or team teaching sessions by low/high number of newsletters and journals produced

The multivariate contrast comparing teachers in regions where low number of newsletters and journals have been produced and those in regions where high numbers of newsletters and journals have been produced on the variable *use of Departmental support* was significant (mult. $F = 4.47$, $p < 0.001$, effect size 0.07). The univariate analysis indicated that the variables contributing to this difference were *teachers' rating of the use of in general the provision of inservice education* ($p < 0.001$), *general advice and guidance from the Department's regional computer education consultant* ($p < 0.001$), *specific advice by the regional computer education consultant on the development of computer-related curriculum materials* ($p < 0.001$), and *involvement of the regional computer education consultant in demonstration lessons or team teaching sessions showing the application of computers to the learning process* ($p < 0.05$). (6.4.4)

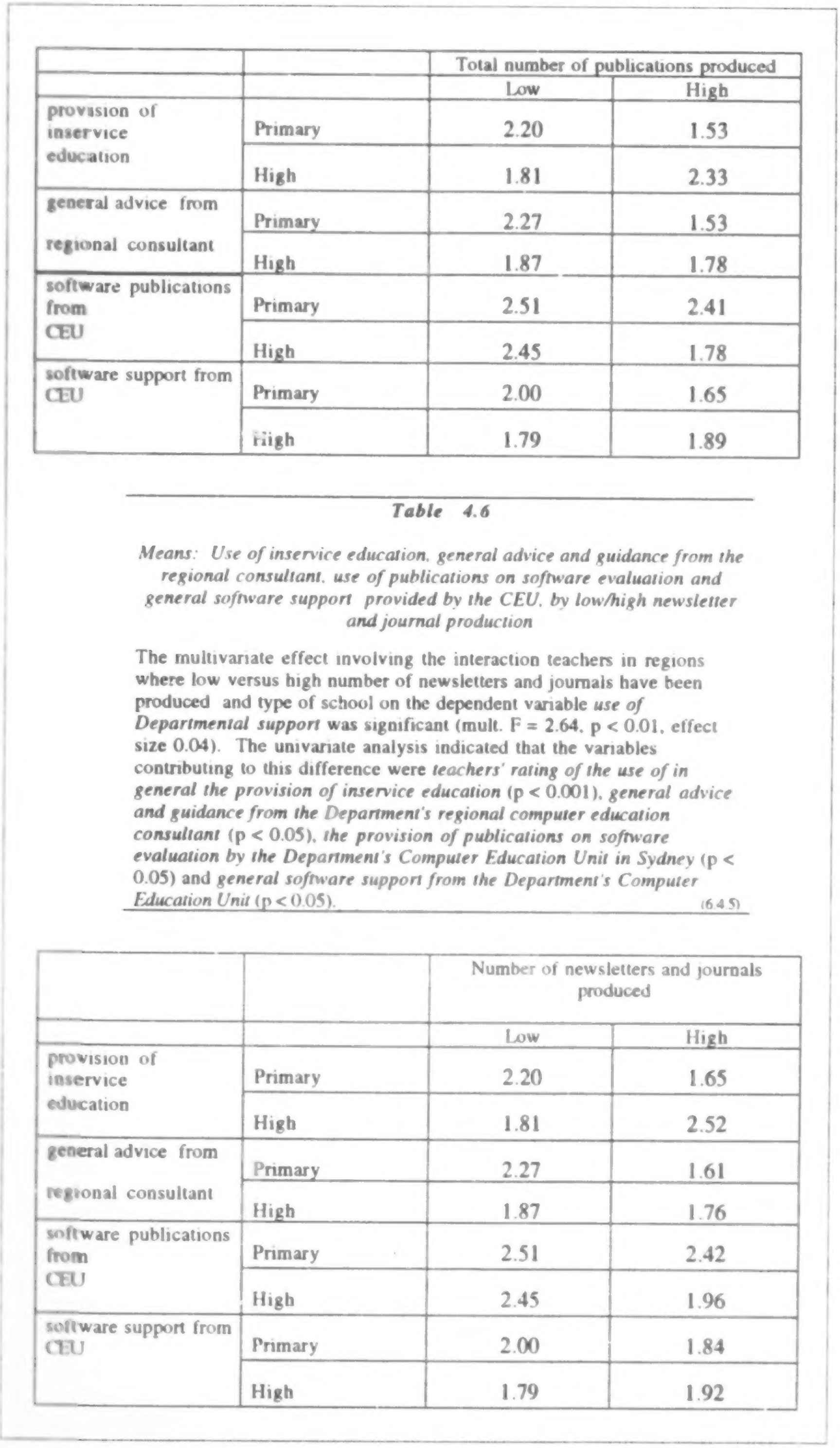
	Number of newsletters and journals produced	
	Low	High
provision of inservice education	2.05	1.96
general advice from regional consultant	2.12	1.89
specific curriculum advice from regional consultant	1.83	1.82
involvement of the regional consultant in demonstration lessons or team teaching sessions	1.63	1.49

Table 4.5

Means: Use of inservice education, general advice and guidance from the regional consultant, use of publications on software evaluation and software support by the CEU, by low/high publications

The multivariate effect involving the interaction between teachers in regions where a low versus high total number of publications have been produced and type of school on the dependent variable *use of Departmental support* was significant (mult. $F = 2.69$, $p < 0.01$, effect size 0.05). The univariate analysis indicated that the variables contributing to this difference were *teachers' rating of the use of the provision of inservice education* ($p < 0.001$), *general advice and guidance from the Department's regional computer education consultant* ($p < 0.01$), *the provision of publications on software evaluation by the Department's Computer Education Unit in Sydney* ($p < 0.05$) and *general software support from the Department's Computer Education Unit* ($p < 0.05$). (6.4.7)

In the case of the high school teachers, the publications may well be assisting them to identify other Departmental support on offer and encouraging them to make use of it. Newsletters and journals identify other publications on how to use computers, what types of software are available and how they may be incorporated into learning programs



		Total number of publications produced	
		Low	High
provision of inservice education	Primary	2.20	1.53
	High	1.81	2.33
general advice from regional consultant	Primary	2.27	1.53
	High	1.87	1.78
software publications from CEU	Primary	2.51	2.41
	High	2.45	1.78
software support from CEU	Primary	2.00	1.65
	High	1.79	1.89

Table 4.6

Means: Use of inservice education, general advice and guidance from the regional consultant, use of publications on software evaluation and general software support provided by the CEU, by low/high newsletter and journal production

The multivariate effect involving the interaction teachers in regions where low versus high number of newsletters and journals have been produced and type of school on the dependent variable *use of Departmental support* was significant (mult. F = 2.64, $p < 0.01$, effect size 0.04). The univariate analysis indicated that the variables contributing to this difference were *teachers' rating of the use of in general the provision of inservice education* ($p < 0.001$), *general advice and guidance from the Department's regional computer education consultant* ($p < 0.05$), *the provision of publications on software evaluation by the Department's Computer Education Unit in Sydney* ($p < 0.05$) and *general software support from the Department's Computer Education Unit* ($p < 0.05$). (6.4.5)

		Number of newsletters and journals produced	
		Low	High
provision of inservice education	Primary	2.20	1.65
	High	1.81	2.52
general advice from regional consultant	Primary	2.27	1.61
	High	1.87	1.76
software publications from CEU	Primary	2.51	2.42
	High	2.45	1.96
software support from CEU	Primary	2.00	1.84
	High	1.79	1.92

for children. The same publications would also identify people who may be able to assist teachers (consultants, local resource people, CEU staff) and courses which may lead teachers to further develop their skills in classroom computer use.

The possible effect on primary teachers may be explained by a different type of publication or different number of publications being sent to primary schools. These publications may have answered many of the questions put by primary staff and so, they felt no need to seek out further Departmental support - a logical aim for all consultants is eventually to train people to the extent that consultancy assistance is no longer required.

Alternatively, the publications may have lead primary teachers to the conclusion that limited assistance was available to them and so, the demand for Departmental support from primary staff was not forthcoming. This would reflect the limited amount of software available for use in primary schools at this time.

In summary, the number of publications produced by a region appears to have little impact on the confidence of teachers. However, teachers in regions where more publications were produced indicated they had been involved to a greater extent in professional development activities. High school teachers recorded greater use of Departmental support in regions where a large number of publications were produced: for primary teacher the result was reversed.

DISCUSSION OF RESULTS OF THE MULTIVARIATE ANALYSES ON THE *CONSULTANT'S USE OF TELECOMMUNICATIONS* VARIABLE

Analyses conducted in this area sought to identify any relationship between the use of *Keylink* (the Department's preferred electronic mail system) and teacher confidence. Two independent variables were constructed: one addressing the use of Keylink for needs identification, a second listing the consultants' rating of *Keylink* as a means of providing assistance to schools (as a picture of frequency of use). Use of *Keylink* for needs identification was indicated in a yes/no response. Consultants' rating of *Keylink* as a means of providing assistance was initially on a scale of one to six (one = very important). Responses were grouped: one to three as "important", four to six as "not important". The assumption is made that if *Keylink* usage is rated as important its use is also high.

The results have indicated that whether or not consultants use *Keylink* to identify the needs of schools there is no significant effect on the confidence of teachers. The result was the same for the use of *Keylink* as a means of providing assistance to schools. Teachers in regions where consultants made greater use of *Keylink* for assisting schools were no more confident than their colleagues in regions where *Keylink* use was low.

It is useful to note however, that teachers in regions where *Keylink* was rated high for use in providing assistance to schools considered they had received more inservicing in computer education. Coupled with the last result, this could mean that teachers consider *Keylink* as a useful form of professional development, but that as yet, it had not led to any greater confidence in the use of computers by teachers.

Overall, teachers reported greater use of inservice provisions, general advice from the regional consultant and specific curriculum advice from the regional consultant in regions where *Keylink* is used more frequently by consultants. It is likely that during electronic mail discussions with staff, consultants are bringing to the attention of school staff inservice provisions as well as providing direct advice.

When differences between metropolitan and country teachers are analysed, it appears that the greater usage of Departmental support lies with the metropolitan staff. They report greater use of inservice provisions, general and specific advice from regional consultants, involvement of regional consultants in demonstration and team teaching lessons and use of software publications from the CEU, when *Keylink* use is high. The reverse consistently applies to country teachers. It is likely that country consultants are using *Keylink* for a different purpose than their metropolitan counterparts. The results would tend to indicate that in metropolitan regions consultants' use of *Keylink* is leading to greater use of Departmental support - perhaps consultants are using the service to help teachers identify where support is available. In country regions, consultants may be using the service to problem solve directly, thus leading to less call on Departmental support by teachers.

When primary and high school teachers are compared, the results indicate that when *Keylink* use is high, high school teachers make greater use of Departmental support. This is the case for the use of inservice provisions for primary teachers, but they seem to make less use of software publications when *Keylink* usage is high. This may be due to advice on software use being received from consultants via *Keylink*.

In summary, the use of *Keylink* made no difference to the confidence of teachers. Teachers in regions where *Keylink* use is more highly rated by consultants, report higher levels of professional development support. Teachers in regions where *Keylink* is more highly rated by consultants record greater usage of Departmental support. Further analysis indicates that metropolitan teachers make greater use of Departmental support when *Keylink* use is high, but country teachers make less use. High school teachers make greater use of Departmental support when *Keylink* use by consultants is high, but primary teachers make less use.

DISCUSSION OF RESULTS OF THE MULTIVARIATE ANALYSES ON THE *DECISION MAKING* VARIABLE

In the surveying of regions, all ten regions reported on the operation of regional computer committees. Six regions indicated that their computer committees took an advisory role. These committees typically provided a voice for a range of people impacted on by the use of computers in education and frequently involved people with expertise in computing specifically. The "advisory" committees usually made recommendations regarding the expenditure of regional computer education funding, but it was the consultants or inspectors in these regions which had the final say on expenditure of funds. Four regions indicated their committees were "determining", that is to say, the regional committee had the final say over expenditure of the region's allocation of computer funding. As a matter of process, consultants were not provided with as much freedom in the organisation of support in these situations. Consultants were also surveyed for the opportunity to have individual input into funding decisions - a "yes" or "no" response followed. This section attempted to identify whether or not this variation in flexibility for the consultants made any difference to teachers' confidence, rating of extent of inservice and use of Departmental support.

In regions where the committees were "advisory", primary teachers consistently rated their confidence in the use of computers higher than those in regions where committees were "determining". For high school teachers the results were orientated the other way. These results may be due to committees which are "determining" placing a greater emphasis on secondary support. While a number of other factors may have influenced this result, it seems that when committees operate in an "advisory" fashion and consultants are permitted more flexibility in which to work, teachers' confidence in the use of computers is enhanced.

The results indicated that in regions where consultants had opportunity for individual input to decision making, teachers were less confident in the use of computers. In regions where funding decisions were made through committee teachers indicated greater confidence. It is likely that, as committees generally had representatives from schools, the Department and tertiary institutions a balance of expertise was available to contribute positively to the decision making. Coupled with the last result, a balance in committee input and flexibility for consultants seems a worthwhile combination.

The results indicated that the type of regional committee operating, or whether or not consultants had individual input to decision making, had no significant effect on teachers' perceptions of the extent of their professional development.

Teachers in regions where computer committees were advisory made greater use of Departmental support than teachers in regions where committees were determining. They made greater use of inservice provisions, as well as calling more frequently on both general and specific advice from the regional consultant. They involved regional consultants in more demonstration and team teaching lessons and called on the CEU more frequently for hardware support. The results also indicated that teachers in regions where consultants had individual input to funding decisions made greater use of Departmental support. Teachers in these regions made greater use of inservice provisions as well as greater use of in-school computer-literate staff.

These results tend to build a case for "advisory" committees and possibly a maintenance of flexibility for consultants in decision making regarding funding in those regions where committees are "advisory" and establishment of such flexibility in regions where they are "determining".

In summary, the results indicate that teachers in regions where computer committees are "advisory" in terms of funding expenditure are more confident users of computers, and make greater use of Departmental support. The type of regional committee operating has no impact on teachers' perceptions of the extent of their professional development.

CONCLUSIONS AND RECOMMENDATIONS

Prior to addressing the results of the analyses between the dependent variables and the independent variables, brief mention is warranted of variations between teachers from metropolitan and country regions, and teachers from schools of different types (primary, central, high and support). Several of the results mentioned here are already a part of the work conducted by Fitzgerald, Woodley and White (1990) used in the formation of the *Schools Renewal* strategy (Scott, 1990). More specific variations between these teacher groups, in the context of this thesis, will be addressed as each of the dependent and independent variables are addressed.

Country teachers have indicated greater confidence in the use of computers than metropolitan teachers. This is despite the fact that metropolitan teachers have rated their instruction time and extent of inservice education greater than did the country teachers. Country regional consultants reported a higher number of interactions with teachers than metropolitan consultants.

High school teachers indicated a greater frequency of use of computer at school than did primary teachers. High school teachers also felt more confident in the use of software. Primary teachers indicated that they received more instruction time and a greater extent of professional development in computer education than high school teachers. Primary school teachers reported that they made greater use of both regional and CEU consultancy than did high school teachers.

Primary teachers estimated they had received more instruction time on computer education than support school teachers. However, support school teachers indicated they were more frequent users of computers and felt more confident to preview programs for class use than primary teachers.

High school teachers indicated they had received more instruction time on computer education than central school teachers, indicated they made greater use of in-school staff with computer expertise and they indicated greater confidence in the use of computers than central school teachers.

Consideration will now be given to each of the dependent variables and their relationships to the independent variables and recommendations that seem to flow from these results.

EFFECTS ON TEACHERS' CONFIDENCE IN THE USE OF COMPUTERS

- The results indicated that the greater the number of interactions teachers had with consultants, the more confident the teachers reported they were in the use of computers.

Recommendation:

Encourage Departmental staff to increase the number of consultancy visits, one day inservice courses, after school courses, extended duration courses and school development days focussing on computer education. (1.1)

- Variations in the number of consultants employed by a region did not significantly relate to teachers confidence in the use of computers. The minimum number of consultants per region addressed by this research was one, the maximum, four.

- The operation of a computer centre, in itself, did not significantly relate to teacher confidence in the use of computers. However, some of the services operating from the centres seemed to have influenced teacher's confidence.

- The loaning of software to teachers for trialling prior to purchase had a significant relationship to confidence of teachers. Teachers in regions where greater numbers of software programs were available for trial indicated greater feelings of confidence in the use of computers across a range of areas.

Recommendation:

Increase the number and range of software programs regions make available to teachers for trialling prior to purchase. (1.2)

- The employment of ancillary staff at regional computer centres appears to have had no direct significant effect on the confidence of teachers to use computers at school. It is possible that these people contribute positively to the operation of inservice activities and/or the mobility of the regional consultants (requiring them to spend less time on office tasks).

- In this research, regions reported a range of between three and thirty one publications produced over the period of investigation. The results indicated that variations in the numbers of publications produced by regions had no significant effect on the confidence of teachers. This includes newsletter, journals, hardware and software guides, teaching notes and the like. It is possible that benefits resulting from this work are directly felt by the people involved in the compilation of the work or that benefits to other teachers may yet be forthcoming.

- The use of *Keylink* to identify the needs of schools, or to provide direct support to schools did not significantly effect teachers confidence in the use of computers.

- Regions reported two types of regional computer committees operated. In one situation committees advised regarding expenditure of regional computer education funds, in the other, the committee determined funding levels allocated to various projects and determined individual purchases.The results indicated that in regions where regional computer committees advised regarding expenditure of computer education funds (as opposed to determining expenditure), primary teachers were more confident users of computers. Secondary teachers were more confident users of computers in regions where the committee determined computer education expenditure than their colleagues in regions where advisory committees operated.

Recommendation:

Expenditure of computer education funds should be tied to a policy framework determined by the regional computer committee. Regional consultants, as managers of regional computer education support programs, should be permitted flexibility in expenditure within broad policy guidelines. (1.3)

EFFECTS ON TEACHERS' PERCEPTIONS OF THEIR EXTENT OF PROFESSIONAL DEVELOPMENT

- The results indicated that the greater the number of consultants employed by a region, the greater the teachers' rating of the amount of instruction time and extent of inservice education received. Logically, as more consultants are employed, more inservice activities are provided to schools. Information put forward by the consultants was confirmed by the teachers within each region.

- The operation of a computer centre did not significantly influence teachers' perceptions of the extent of their professional development. However, in regions where the provision of computer software for trialling was high, teachers also rated the extent of their professional development high. This finding supports recommendation 1.2.

- The employment of ancillary staff at regional computer centres appears to have had no direct significant effect on the teachers' perceptions of their extent of professional development. As indicated earlier their employment may have assisted consultants in ensuring the quality provision of such activities.

- High school teachers rated their instruction time and extent of inservice education higher in regions where higher number of publications were produced. Primary school teachers indicate more instruction time and a greater extent of inservice education when the number of publications produced is low. Information was not available on the focus (primary or secondary) of publications produced.

Recommendation:

Publication of support materials be encouraged, with the proviso that a balance is maintained between secondary-oriented and primary-oriented publications produced. (2.1)

- Teachers reported a greater extent of inservice provisions in regions where the consultants made greater use of *Keylink* as a means of providing support.

Recommendation:

> *Use of Keylink as a means of providing support to teachers be encouraged. (2.2)*

- The results indicated that the type of regional computer committee operating had no significant effect on teachers' perceptions of the extent of their professional development.

EFFECTS ON TEACHERS' USE OF DEPARTMENTAL SUPPORT

- The number of interactions between consultants and teachers had no significant impact on the teachers' use of Departmental support. Teachers in regions rated high for number of interactions with consultants, did not rate any higher (or lower) for use of Departmental support than teachers in regions rated low for numbers of interactions with consultants.

- The number of consultants employed by a region did not significantly affect teachers' use of Departmental support. Despite the fact that some regions employed a greater number of consultants, teachers reported no greater use of inservice provisions, advice from regional consultants or assistance from the CEU.

- The operation of a computer centre did not, in itself, lead to variations in teachers' use of Departmental support. Teachers in regions with higher numbers of software programs available for trial indicated greater use of Departmental support than colleagues in regions rated low for amount of software available. This finding further supports recommendation 1.2.

- Primary school teachers rated their use of Departmental support higher in regions where ancillary staff were employed in the regional computer centre. Results were not significant for high school teachers.

Recommendation:

> ***Ancillary staff should be employed to assist in the operation of regional computer centres (where operating). (3.1)***

- High school teachers in regions where higher numbers of publications were produced reported greater use of Departmental support than colleagues in other regions. Primary teachers made less use of inservice provisions and consultancy advice as more publications are produced.

- The results indicated that when *Keylink* use by consultants is high, both primary and high school teachers make greater use of Departmental inservice provisions. Primary teachers, seem to make less use of software publications when *Keylink* use is high, perhaps indicating that they are receiving software advice via *Keylink* in these regions. These findings support recommendation 2.2.

- Teachers in regions where regional committees take an advisory role have indicated they make greater use of Departmental support than their colleagues in regions where the regional computer committee adopts a "determining" role. This finding supports recommendation 1.3.

FUTURE RESEARCH

Following extensive searching of the literature, it is apparent that very little research has been conducted into the computer education support programs of Education Departments, in particular their regional branches. The work of Nanlohy (1985, 1986, 1988) and Morgan (1991) has reported on models of staff development in use in supporting computer education in NSW schools. Miles et al (1988) have identified key skills for agents of change in general and unrelated specifically to computer education. It is notable then, that apart from this thesis, no other research programs have been identified which address variations in NSW regional computer education support programs and the resultant confidence levels of teachers in those regions.

Clearly, as the development of computer use in schools is at such an earlier stage (little more than a decade in reality) the time span for research has been short. The scope then, for further research is quite broad.

This research has answered some questions, however many more are raised. Within some of the areas of analysis, more detailed research is warranted. For example, ***in which areas do computer consultants need more training (more particularly because of their area of work)?*** The current research suggests a need for more detailed investigation of the kind of skills needed by computer consultants in education. This is consistent with the findings of Miles et al (1988). Such research could identify key skills required in computer education consultants so that the most effective support and training programs are offered.

What makes a more effective computer centre? This research has indicated that some services may have a significant effect on teacher confidence (in particular the loaning of software for trial prior to purchase. The merits of producing some types of publication have been questioned - *which publications are of use to the reader and which yield most benefits only to those involved in its writing?*

It seems that only minimal use of a significant resource is made where electronic mail is concerned. The use of electronic mail for training, complementing communication networks, and providing consultancy assistance appear largely unrealised at present. Significant scope exists for research into models of training staff in the use of computers and their application to education.

Results in this research indicated primary school teachers were more confident users of technology where regions operated advisory regional computer committees. In regions where computer committees made firm decisions regarding the expenditure of computer education funds (determining committees), secondary teachers rated their confidence higher. While the recommendations in this thesis attempt to satisfy the needs of both groups, it is likely that other areas of Departmental support (not covered in this research) will provide a better environment for developing the confidence of teachers.

An underlying assumption in the above comments is that state support for computer education will continue. Survey responses by teachers have clearly indicated a need for ongoing support for the training of staff in the use of computers in education. *What is an appropriate level of teacher confidence in the use of computers? (Self autonomy?) How will the system gauge that staff have arrived at that point?*

June 1992 marked the conclusion of a very significant period of funding for computer education in NSW schools. Over the previous four years in excess of $64 million of government funding has been spent in state schools on computer education. This funding has addressed the purchase of hardware, software and published resources, the professional development of teachers, the training of computer education coordinators, the establishment and development of computer classrooms, the use of electronic communications services, and increases in consultancy support. Coupled with this there has been significant change in the management structures operating within the NSW education system, providing much greater flexibility for local determination of priorities for development.

As this research has provided a benchmark for the state of regional support of computer education to the end of 1988, the time is opportune for further research addressing change since 1988. Each of the areas focussed on by the state funding program could provide specific research issues, but perhaps more importantly issues relating to change in teacher and student confidence with computers should be addressed. The current work and the work of Fitzgerald and Fitzgerald (1990) and Fitzgerald, White and Woodley (1990) provide measures from which subsequent research could gauge changes in the computer expertise of students, teachers and principals. Fitzgerald et al provide future researchers with relevant data from students, teachers and principals. This work contributes information relating to regional support programs.

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APPENDIX

Questions from Major Questionnaire - required for interpretation of tables.

Q10: Estimate how many hours you have had of instruction time on computer education.

None	1
Less than 3 hours	2
Between 3 and 10 hours	3
Between 10 and 40 hours	4
More than 40 hours	5

Q12: What is the extent of inservice courses you have had in computer education?

None	1
A few hours	2
About one week	3
About one month	4
One semester	5
More than one semester	6

Q14: At school, how often do you use a computer for any purpose?

Never	1
Very rarely	2
Once a week	3
A few times a week	4
Almost every day	5

Q17: How well can you do the following tasks related to the use of a computer?

	Not at all				Very well	
Use a word processor	1	2	3	4	5	6
Use an administrative program	1	2	3	4	5	6
Use a database program	1	2	3	4	5	6
Evaluate programs students are using	1	2	3	4	5	6
Use a spreadsheet program	1	2	3	4	5	6
Preview a program for use in your class	1	2	3	4	5	6

Q20: Are you involved in any computer activities in your present school?

No	Yes
1	2

If you answered NO then you are finished the questionnaire.
If you answered YES then please complete the rest of the questionnaire.

Q21: Circle a number to indicate the level of Department of Education support used by your school with respect to computer activities

	None				Extensive	
In general, the provision of inservice education	1	2	3	4	5	6
General advice and guidance from the Department's regional computer education consultant	1	2	3	4	5	6
Specific advice by the regional computer education consultant on the development of computer related curriculum materials	1	2	3	4	5	6
Involvement of the regional computer education consultant in demonstration lessons or team teaching sessions showing the application of computers to the learning process	1	2	3	4	5	6
The provision of publications on software evaluation by the Department's Computer Education Unit in Sydney	1	2	3	4	5	6
General software support from the Department's Computer Education Unit in Sydney for the equipment in this school	1	2	3	4	5	6
Hardware support from the Department's Computer Education Unit in Sydney for the equipment in this school	1	2	3	4	5	6
The provision of teaching staff for this school with appropriate training and experience in computer applications	1	2	3	4	5	6
The provision of funds to purchase computer hardware and software	1	2	3	4	5	6
The provision of time for teachers to upgrade their computer skills	1	2	3	4	5	6

COMPUTERS AND COLLABORATIVE INTERACTIONS

BY KATHY K. WATSON
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There is a need for information relating to effective computer education in primary classrooms. This paper discusses the computer as a tool and situations which may provide opportunities for collaborative interactions.

Computers and the vast array of programs are only valuable if they contribute to the teaching and learning process. For teachers, computer software should provide a context for the construction of understanding which meets an existing curriculum goal. Teachers must decide if using a computer is the best choice for the task, if the computer's capabilities meet an educational need and if it can be effectively integrated into the existing curriculum.

Today's challenge for teachers is to provide a range of activities which sustain high interest and offer valid purposes to promote active learning. Effectively used, computer software can engage children in a range of situations such as investigations, discovery, communication and problem solving. The experience of students sharing computers provides real purpose and motivation for collaborative work which requires cooperation and communication skills.

COMPUTERS AND COLLABORATIVE INTERACTIONS

Although the amount of hardware and software in classrooms has increased significantly in the last decade (Knight and Watson, 1992; ten Brummelhuis and Plomp, 1991), there has been little progress in integrating computers into existing classroom practices in primary schools. A need exists for information relating to effective computer use in primary classrooms. This paper discusses the computer as a tool which provides situations for collaborative interactions in classrooms.

EFFECTIVE COMPUTER USE AND IMPLICATIONS FOR PRIMARY CLASSROOMS

Computers have been clearly established as an appropriate form of educational technology (Niess, 1990; Polin, 1990; Ray, 1991a,b). A recent study of the Northwest Region of New South Wales provided a sample of teachers' perceptions regarding the effective use of computers in primary classrooms. "Generally, computers were regarded as useful educational tools which prepare students for the future and teachers believed that all students needed to know how to operate a computer" (Knight, and Watson, 1992, p.202). However, responses consistently indicated that the actual levels of skill, experience and knowledge about the uses of computers as educational tools were minimal. There was general agreement that more knowledge about the uses of computers as educational tools would be beneficial

Debate about how computers should be used in classrooms will continue and not all educators will come to the same conclusions. This is to be expected since a wide range of opinions exists regarding appropriate learning environments, including the role of computers.

Ultimately, classroom teachers must decide if a computer is the best tool for a particular task, if computer software meets an educational need and if computer use can be effectively integrated into an existing curriculum. These decisions are based on personal beliefs or views about learning processes. If teachers believe that all knowledge is constructed, instruction is a nurturing of these processes, and accept that literacy development is a social event, then their classrooms should provide experiences to facilitate this construction process. Central to this view of constructivism is the notion of the learner "as 'active' not just responding to stimuli, as in the behaviorist rubric, but engaging, grappling, and seeking to make sense of things" (Perkins, 1991). Perkins states that "learners do not just take in and store up given information. They make tentative interpretations of experience and go on to elaborate and test those interpretations."

Software should be selected because it offers opportunities for students to engage in an interactive learning process. Teachers will need to have skills for selecting and evaluating software to meet specific goals and that process will be greatly influenced by a teacher's assumptions about how knowledge is constructed.

HOW WILL TEACHERS DECIDE IF USING A COMPUTER IS THE BEST CHOICE FOR THE TASK?

Computer use and appropriate software should provide a context to enhance student understanding and meet an existing curriculum goal. Since many schools have a limited number of computers, students sharing computers can provide an excellent situation for communication and collaborative skills. This paper presents support for using educational adventure games which can provide real purposes for practising many language skills and offer challenging reading experiences.

Teachers can select software which provides a situation that promotes interactive, cooperative learning and provides experiences to use language for a variety of purposes. Some interactive software can support a functional approach to language by providing a context for using language naturally. A functional approach to language looks at how language enables us to do things - to share information, to enquire, to argue, to reflect, to construct ideas, and make sense of the world. The emphasis is on meaning and on how language is involved in the construction of meaning (Derewianka, 1990). Selected software then can provide collaborative experiences that will promote active reading, expand experiences and enhance learning.

Growing research evidence is converging on a view of the reading process as transactions between reader and text which results in construction of meaning. This view regards the role of the reader as a highly active one. Goodman, Smith and others emphasise that "reading is meaning-seeking, tentative, selective and constructive... they all emphasise the importance of inference and prediction in reading" (Goodman, 1985). Students sharing the task of reading computer text for a common purpose are in an excellent situation for shared understandings to evolve as they read, discuss, make decisions and clarify meaning.

Collaborative small group computer work presents a situation for students to construct mutual understandings of text and to take responsibility for their own learning. Newman, Vibert, Freeman, and Sharp (1988) point out that computers encourage collaborative learning, even in story games. The games seem to generate comprehensive, collaborative problem solving activities. Carefully chosen educational games can promote classroom interaction, encourage student planning and decision-making and become an important part of the computer-literacy events in the classroom
(p. 435). Students naturally collaborate and use language to enhance and clarify their thinking when playing computer games.

HOW CAN COMPUTER USE BE EFFECTIVELY INTEGRATED?

Computer programs can be chosen to compliment existing curriculum goals. Classrooms designed to encourage problem solving, critical and creative thinking can use a variety of programs such as: adventure games, graphics, simulations, and integrated software programs. Teachers can provide software as a motivation to read for a variety of purposes. Simulations can encourage students to apply higher order thinking skills involved in making decisions, and analysis of outcomes. Adventure games can promote cooperative learning and guide reading for information. The most effective simulations/adventure games incorporate cooperative effort, and research beyond the computer screen.

The reality of integrating computers in any classroom depends on the structure of the learning environment and the underlying assumptions held by the teacher about the nature of teaching and learning. Constructivist instruction generally confronts learners with situations that challenge them to ponder, compare, contrast, reflect and construct understanding. "Information processing technologies offer special help, because they allow building the kinds of more intimate, supportive, learning environments called for by the constructivist perspective .... together, information processing technologies and the constructivist point of view fashion an image of education much more attentive to understanding and the active use of knowledge and skills" (Perkins, 1991). (For additional information about integration, see the Appendix: Curriculum Correlation for Where in the World is Carmen Sandiego?)

AN EXAMPLE: WHERE IN THE WORLD IS CARMEN SANDIEGO?

There are many excellent computer programs available now. The following program is presented only as an example to clarify the role of a computer as a tool which can provide situations for collaborative interactions in classrooms.

Where in the World is Carmen Sandiego? is an example of an excellent interactive adventure game now available in a Multimedia version. The players (detectives) have the task of solving a string of crimes which involves an intriguing chase to many destinations around the world The game effectively incorporates the need to research clues in the World Almanac, read to learn about different parts of the world and to work cooperatively and collaboratively. The mystery in this adventure game provides students with a challenge, real purposes to communicate using a variety of language skills and a social context for critical reading and discussions.

Students are naturally drawn to the game situation and easily engage in the investigations and problem solving situations presented to them. This collaborative learning situation fosters discussions that allow different points of view and exchange of ideas which all contribute to the development of creative thinking and deeper levels of understanding (Cunningham, Knight, and Watson, 1992). The student detectives share creative inquiry (trying to solve the crime) as they learn how to: ask the right questions (a kind of critical curiosity); investigate and interpret (reading for specific relevant details); reconstruct text (using clues found in the original text), and use prediction to draw tentative conclusions (problem solving).

The software creates a context, motivation and purpose to use all forms of language: speaking, listening, reading, and writing. Two or three students working together with this instructional adventure game will have many opportunities to use a variety of reading strategies. In an effort to make sense of the text, they will actively read by sampling and selecting text; and using inference, prediction, confirmation and correction strategies. Investigating the crimes provides real purpose for reading and discussing information on the screen as well as from the World Almanac. Feedback supplied by the software allows students to self monitor and to evaluate their experiences. This feedback can also promote strategy analysis (often through naturally occurring talk) to help students learn more about their personal metacognitive strategies and problem solving approaches.

Teachers have a powerful tool and the ability to significantly alter instruction with the availability of computer software, especially Multimedia. Appropriate and effective use of computers must consider software which places a high cognitive demand on students. Software should offer students an opportunity to apply skills and knowledge, to evaluate and make judgements and to draw together selected bits of information in order to solve problems. Ideally, students will use computers as a tool to enhance their own thinking and to achieve goals which goes beyond the acquisition of isolated facts.

To summarise, many educators do not fully comprehend the implications of computer use in schools and many questions remain regarding the future roles of teachers and computers. Computer applications can motivate student to engage in many essential future skills such as higher order thinking. Teachers must decide if using a computer is the best choice for the task, if the computers' capabilities meet an educational need and if software can be effectively integrated into the existing curriculum. Are educators willing to meet the challenge, to review personal views of learning and current practices, to provide necessary support to integrate computers into classrooms?

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COMPUTER HARDWARE- SOFTWARE AND ORGANISATION WITHIN PRIMARY SCHOOLS: AN EXPLORATORY STUDY INVOLVING SCHOOLS IN THE NW REGION OF NSW, AUSTRALIA

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Computer coordinators from 11 primary schools responded to a survey designed to gauge the amount of computer hardware, software and organisation within their schools. The schools were from a rural area of NSW and ranged in size from less than 50 to more than 500 pupils and the number of computers in the schools ranged from 2 to 14.

Generally, the most common types of software found in the schools were problem solving, creativity and thinking skills, and utilities (eg. Print Shop, Crossword Magic). There appeared to be no uniform organisation regarding software purchase or storage nor responsibility for hardware and software within the schools. Some respondents indicated that computers and software were high on a list of priorities for their schools and there were limited funds available for such purchases. Although computers were commonly used in the schools, less than half of the schools had provided any computer inservice training for teachers.

These findings, if replicated in future studies, have implications for both preservice and inservice teacher education.

BACKGROUND TO THE STUDY

Computers have been clearly established as appropriate technology for education (Ahearn, 1991, Niess, 1990; Polin, 1990; Ray, 1991a,b). An earlier study of teachers in the Northwest Region of New South Wales (Appendix A[1]) provided a sample of their perceptions regarding the effective use of computers in primary classrooms. The conclusion drawn from this can be summarised as "Generally, computers were regarded as useful educational tools which prepared students for the future and teachers believed that all students needed to know how to operate a computer" (Knight and Watson, 1992, p. 202). Responses consistently indicated the actual level of skill, experience, and knowledge about the uses of computers as educational tools was minimal. There was general agreement that more knowledge about the uses of computers as educational tools would be beneficial (Knight and Watson, 1992).

If educators are promoting the use of computers in classrooms and funding for hardware and software, then computers are in the schools to stay and teachers must learn to make the maximum use of them. How then is computer hardware and software organised within schools? What are the implications of this organisation for effective use of hardware and software by teachers and students in primary schools?

This pilot study aims to provide preliminary information from a sample of school principals and/or computer co-ordinators in the Northwest Region of New South Wales who responded to a survey regarding their current organisation of computer hardware and software in schools.

AIMS OF THE STUDY

1. To gather information from a sample of primary principals and/or computer co-ordinators to gauge the amount of computer hardware, and software and its organisation within schools.
2. To describe the current situation regarding computer organisation in the Northwest Region of New South Wales.
3. To document the implications of such organisation for preservice and inservice education.

METHOD

SAMPLE

From reply-paid surveys distributed to twenty schools ranging in size from two to thirty teachers, 11 were returned. This sample of respondents represented schools catering for less than 50 to more than 500 students.

INSTRUMENT

A survey (see footnote re Appendix B) was designed to gather information from principals/computer co-ordinators to gauge the amount of computer hardware, and software and its organisation within schools. The first section consisted of four questions relating to the number of computers, type and amount of software and organisation within the school. Respondents were required to provide numerical data for these questions.

The second section of nine questions referred to the school's organisation and funding of hardware and software and the principals/computer co-ordinators beliefs regarding the use of available funds, uses and priorities of computers in their schools. A five-point Likert scale was used to assess beliefs, with categories ranging from strongly agree to strongly disagree and from none to very much. The final three questions dealt with how the school provided inservice training for teachers and kept up to date with new developments needed to use a computer effectively in the classroom.

The survey responses were completely voluntary and anonymous, with the period taken to complete it ranging from 10 - 15 minutes.

PROCEDURE

The 20 surveys were distributed with reply paid envelopes to a sample of primary schools in the Northwest Region of NSW. After a period of three to four weeks, 11 responses were received. The Statview computer package was used to analyse the quantitative data.

RESULTS

Because of the small number of respondents to the survey, any conclusions stated cannot be generalised to all schools. They can however, be used to describe the situations as they currently exist in some schools.

SECTION ONE

The number of computers in schools varied between two and fourteen. As expected, the number of computers in each classroom, and organisation within infants, middle and upper primary areas varied considerably. There were no computers laboratories, all of the computers being located in individual classrooms. There was a wide variety of amount and type of software with utility and problem-solving programs being the most popular. The least often found software in these schools was Logo (see Figure 1).

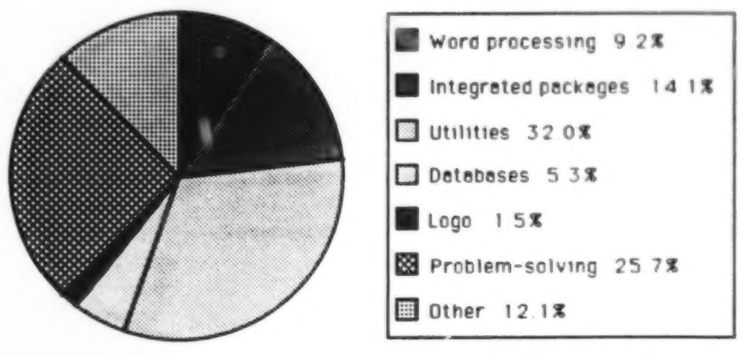

Fig 1: Software Usage

SECTION TWO

A majority of responses to question 6 on the survey (responsibility for hardware and software) suggested that individual teachers at a school were responsible for both computers and software. Other responses indicated that one person at the school was responsible for both hardware and software while no responses suggested that a committee or others had responsibility for this essential task.

Responses concerning software storage suggested that most material was stored in individual classrooms. There was no indication of a centralised listing of software in the schools and where it was housed. Because no central storage facility was used, teachers (especially those new to the school) would presumably not know of all the resources that were available. Does such a situation suggest that some software is only applicable to one grade level and not suitable to others?

The question regarding sources of funding for hardware and software drew general agreement from respondents in that all funding was generated by the actions of persons associated with the schools. For example, most funds were supplied by parent organisations such as 'Parents and Friends' of each school who presumably thought the purchases were essential for their children to remain in touch with modern technology and prepare them for the future.

Not all schools however, ranked hardware and software high on a list of priorities (see Figure 2), and indicated there were only limited funds available. In general the use of computers in the schools also varied from 'a little' to 'very much' (see Figure 3).

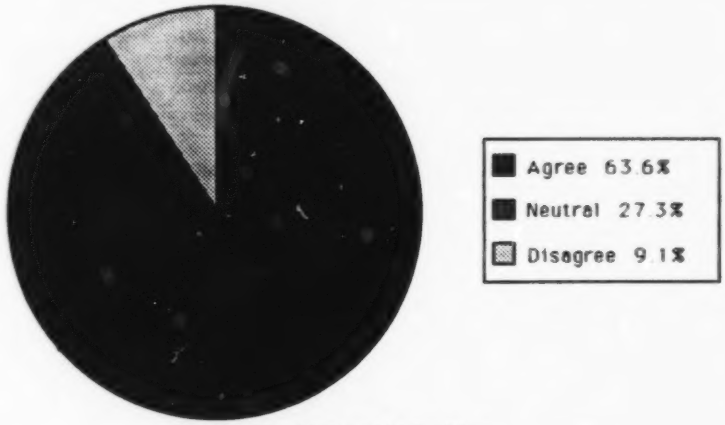

Fig 2: School Priorities

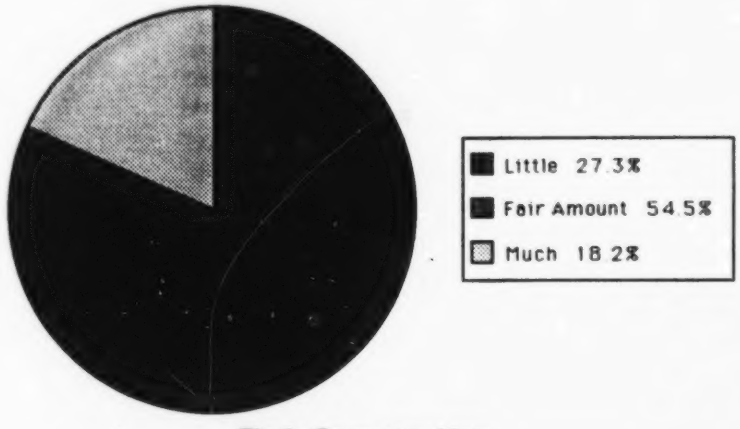

Fig 3: Computer Use

SECTION THREE

Responses to the questions concerning inservice provisions for staff were also varied and ranged from none (55%) to programs that were completed several years ago to those that were happening now. Generally those schools who had provided inservice had done so in more than one area (beginner courses, software usage, problem solving and management). Of concern however is the high percentage of schools who have not provided any inservice and the implications of this will be discussed later.

DISCUSSION

Even though schools appear to have satisfactory resources in the form of hardware and software, the lack of centralised organisation in schools may be hindering the most useful application of these resources. The present system of grafting these resources onto the school and the curriculum will not result in effective use in the classroom.

There are a number of issues to be resolved before computers will be effectively integrated into classroom practices. Teachers must decide if using a computer is the best tool for the task, if the software meets an educational need and if computer use can be effectively integrated into the existing curriculum. Therefore teachers will need to have skills for selecting and evaluating software to meet specific needs. These decisions are greatly influenced by a teacher's assumptions about how knowledge is constructed, and a teacher's expectations and philosophy of education. Do teachers feel computers are drill and practice machines or powerful tools for developing thinking?

If teachers believe that all knowledge is constructed, their classrooms should provide a variety of experiences with the construction process. Some general purpose programs, can offer excellent opportunities for students to construct or create useful information. Word processors, graphics, and database managers are examples of general purpose programs which are beneficial since they are "information free" by design. A major benefit of an "information free" program is that it offers students a tool to assist with many basic processes of organising data, creating, storing and manipulating information for personal purposes. Such experiences encourage students to become responsible for their own learning.

Teachers have a powerful tool and the ability to significantly change current instructional practices with the availability of computer software, especially Multimedia. Ultimately, teachers must decide how computers can be effectively used in classrooms and those decisions require time to review and evaluate software, to collaborate with colleagues and resource people. Inservice provisions to allow teachers to firstly explore the hardware and software and then to experiment with these tools in their teaching practices will benefit the educational system by supporting effective classroom teachers and active learners with this new technology.

The findings of this small pilot study forms the basis of a larger future study needed to explore the organisation and use of computers in schools. If similar results are obtained, then there is a need to provide support to schools and teachers so that computers can be effectively integrated into the school system.

The broader implications of the results of this study suggest that ongoing support is a major concern for teachers. It is therefore necessary that a system for providing support is created to meet this need. Addressing these needs within schools is necessary to inspire teachers, to overcome hardware deficiencies, and to enable resources to be effectively used in the classroom.

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[1] Appendix A and B have been omitted from this version of the paper in order to reduce the length of the document. Please see authors for further information about these survey forms Department of Learning, Development and Communication, University of New England, Armidale, NSW 2350 AUSTRALIA (Ed.)

THE NATIONAL VISION FOR TECHNOLOGY EDUCATION - DO THE POLICY MAKERS HAVE A CRYSTAL BALL?

BY ARNA WESLEY
NSW Representative ACCE

This paper aims to illuminate the pathways which led to the development of the National Technology Project. A number of questions are posed, but few answers are provided. Various systems, groups, procedures, bureaucracies, individuals etc will be involved in the implementation of this national initiative - Will they form stepping stones, or will they be stumbling blocks?

The discussion of the development of the Technology Project is historical in character and provides an overview of the past and present situation for technology in the school curriculum. The context in which these changes are occurring is analysed, with some deliberation on the situation in the United Kingdom and the United States. Technology Education is discussed in the light of a study of the literature, and this is related to the Australian, and in particular, New South Wales, curriculum. It is noted that there is some tension between decentralisation at a state level and the centralisation of curriculum at a national level.

The results of a survey conducted at the last national conference - ACEC '92 - are included. They raise questions about the consultation with technology educators. The process of implementation has received little emphasis in official communications. How will these initiatives manage to find their way, via the bureaucracy to the technology education teachers, and finally to the most important stakeholders - the students? Time will tell. As technology educators, we must prepare ourselves for the launch of the National Technology Project.

INTRODUCTION

Some may say that education is being inundated with change, while others will say that there is nothing new at all. It is sometimes stated that policy changes are made with little knowledge of the classroom situation, while a policy-maker may state that teachers are resistant to change. It cannot be denied that schools are embroiled in both small and large scale change. There is no doubt that the context in which any initiative occurs will influence the final result. Those who must cope with the change, need to reflect and understand both their own situation and the situations of others around them, in order to plan or cope with the change.

Change has always been with us, interacting with the world around us and providing new challenges. Society has moved through the agricultural revolution and the industrial revolution to face the challenges of the technological revolution. The 1990s have witnessed many internationally significant changes already - Democracy has swept across Europe; the Berlin wall has been removed and Germany reunited; one party systems are on the retreat in Africa; Iraq invaded Kuwait; there is a greater emphasis on social justice.

Toffler (1980), in The Third Wave refers to the "colliding waves of change". He discusses the political, social and economic trends which interact and challenge old assumptions. "We explore the many new relationships springing up - between changing energy patterns and new forms of family life, or between manufacturing methods and the self-help movement, to mention only a few - we suddenly discover that many of the very same conditions that produce today's greatest perils also open fascinating new potentials." While he focuses on the direction of change, he also warns of the cost of not being fast enough in making changes.

In the Australian context similar warnings are given by Jones (1990) in the preface to Sleepers, Wake. "Technology could change our perceptions of the world and increase individual capacity exponentially, but failure to come to grips with the social implications could lead to personal retardation rather than advance." He describes how Australia has developed into a new type of society with different economic bases, and how knowledge and skill have replaced raw materials and muscle power or the imperative to work harder.

Vice President Gore, as a senator in 1991, stated that he believes that the United States must remain at the cutting edge of computer technology if it is to be successful in this global civilisation. In referring to the lead in weaponry technology demonstrated in Iraq, he states: *"This same technology is securing our economic security by helping American scientists and engineers to develop new products and processes to keep the US competitive in world markets."* (District of Columbia, 1991)

In providing advice for policy makers, there is little difference between the advice of Toffler in 1970 and Jones in 1990. Both urge the formulation of positive technological goals, in response to the pace of change.

Boyd (1988), Fleming (1987), Jones (1990, Nickerson (1990) and Toffler(1980) agree that technology questions cannot be answered in technological terms alone. Political, social and economic consequences must be considered within the social, cultural and psychological environment. To use Toffler's metaphor, the waves of change in each of these areas, "collide and overlap", creating the society in which we live today.

Education has responded to these changes and, as reported in the United Nations Development Program Report (1991), education systems continue to respond to the challenges set by society.

Australia has shared in the educational revolution of increased participation, and has also experienced changes in educational thinking, and participation/responsibility. Foster and Harman (1992) express surprise at the fact that educational change occurs within such a strong institution.

"Specific factors that might create resistance to change, let alone reform, include a high degree of administrative centralisation, rigidity in bureaucratic organisation, professionalisation and unionisation of teachers, a comparatively low level of community participation in school (and, more generally educational) politics, inertia in the clientele, excessive reliance on credentials and biases on class, gender, ethnic or racial grounds. Despite these factors, however, change does occur." .

Many writers point to the rapid changes in technology as a major thrust in educational development. As Nickerson (1990) states:

"To the extent that the purposes of education are determined by the context in which it occurs, technology by virtue of its role as an agent of social change, is a force in shaping them. Technology also affects the content of education, because among the objectives of education is that of making understandable the world in which one lives, and we live in a technological world."

NATIONAL CURRICULUM

"There is a widespread tendency of central governments not only to achieve or maintain control but also to seek major changes, at the national level, in school curriculum and assessment. ..... The concepts of a common, core curriculum, key competencies, progression through nationally defined and assessed levels or stages, are now common place in countries which only a few years ago saw no place for them" (Skilbeck, 1992)

THE UNITED KINGDOM

In the United Kingdom, in 1988, the Conservative Government introduced the Education Reform Act which provided for a National Curriculum. It furnished government with the responsibility for legislating for

1) the subjects which were to form the basis of the curriculum,
2) assessment of learning, and
3) the development of management policies for schools.

Moon (1992) describes this move as an *"overtly and unashamedly political act;......... an audacious, perhaps unique intervention to restructure radically a national tradition of curriculum organisation and control"* He traces the development of national curriculum from the "Revised Code " of 1862, commenting that the concept of a national curriculum was accepted, but directing criticism at *"the stark, traditionalist model that subsequently passed into legislation without any major modifications"*.

Stringer (1991) agrees that the political influences have been paramount in the United Kingdom experience. It *"is another example of politicians' inability to understand the complexity of how to implement change. The number of changes to the system are indicative of the way politicians are unable to foresee the unintended results of their policies and the way governments shift their ground as they identify the detailed implications of their policies and their problems."*

This National Curriculum in the United Kingdom provides ten foundation subjects to be taken by all pupils during their period of compulsory education. The core subjects (Education Reform Act of 1988) are:
English , Mathematics and Science
The others are listed as: a modern foreign language (in secondary school), technology, history, geography, art, music and physical education.

Each of these studies has a statutory 'program of study' and specified 'attainment targets' for individual student assessment. The National Curriculum Council and the Schools Examinations and Assessment Unit, are the national bodies supervising the implementation.

The early experience of implementation is related by Moon (1992).

"Despite stringent protests about the pace and extent of change, and the form of some of the subjects, surveys show that teachers have accepted the principle of national curriculum. Professional and academic comment has been critical of much of the development process. This comment has been borne out in practice by almost immediate changes in some key aspects of the structure and subject formulations." - eg the National Curriculum Technology.

The Engineering Council (Smither and Robinson; 1992) is critical of the National Curriculum Technology. It provided a detailed report based on comprehensive research, detailing the problems experienced by teachers, and comments that "many of the difficulties seem to be associated with a progressively generalised and abstract notion of 'technology'." The National Curriculum Council responded in 'National Curriculum Technology: The Case for Revising the Order' (1992) which suggests changes as essential if " the Order is to meet the objectives of the Education Reform Act". The recommendations do, however, support the conceptual approach to the technology process which integrates analysis, problem solving, practical capability and evaluative skills.

It must be noted that the national initiative in Australia differs from the United Kingdom situation. Our 'national curriculum' takes the form of a statement which will provide a framework to systems, who have agreed to support the statement. How this occurs will be up to each system.

THE UNITED STATES OF AMERICA

A fundamentally decentralised system of education operates in the United States. The federal government is responsible for educational statistics, research and improvement, and for implementing specific functions mandated by Congress. However, the states hold constitutional responsibility, and this responsibility is passed to the local schools systems.

In 1983 the report The Nation at Risk was released, prompting debate on the quality of education. Seldon (1991) reports that no state comparisons were made at this time because no meaningful data was available. However A Wall Chart was released soon after, and this provided data on each state - including the Scholastic Aptitude Test Scores. The states, as Seldon reports, responded with a movement into assessment and accountability.

Kratzenmeyer (1986) comments that the curriculum was in state control and that the federal role was to collect and collate information. Harmen (1991) believes that although there is no national curriculum, it is the national emphasis on national tests that is driving the curriculum at state level, constituting a de-facto national curriculum.

Seldon (1991) expresses concern at the ability of a decentralised system to set the performance goals established at a national level.

AUSTRALIA

Foster and Harman (1992) trace the changes in policy making in Australian education. They state that *"for policy-making machinery to become active, some issue or issues of significance need to arise that provide impetus for change. .... A single trigger mechanism can operate, or a series of incidents or interplay between incidents can occur, to induce initiators into transforming a concern into an issue that will become a political issue."* They list technological change, social change, and unemployment among others.

The economic problems of Australia are significant in Neil Dempster's (1992) editorial. "As Australia's politicians seek solutions to our economic ills, the contribution that all public institutions make to national productivity has been subject to scrutiny. Education has been no exception." Fasano and Winder (1991), and Kennedy (1992) express similar views, emphasising the influence of political and economic reform.

Historically and constitutionally, education has been the responsibility of the individual states and territories. Foster and Harman (1992) outline the change of educational control, showing that the federal government role in funding for post secondary education in 1950s and the introduction of 'State Aid' during 1960s and 1970s began the trend, but that accelerated change occurred with the creation of the national Curriculum Development Centre (later to become under the auspices of the Schools Commission) in 1980s. The arrival of the Curriculum Development Centre formalised the participation of the Commonwealth in the area of curriculum and legitimised the concept of national curriculum development.

There were examples of cooperation between the Commonwealth and the States on curricula in the 1960s - eg. curriculum planning associated with introduction of the metric system and decimal currency; Australian Science Education Project. Appendix 1 in Fasano and Winder (1991), lists selected government reports and policy documents in Australia from 1980 to 1990, tracing the wave of reflection and reform in Australian education. Such a list demonstrates the changes in focus - from teacher education, to equality and special population groups, to concerns with efficiency in education and training.

The Commonwealth Schools Commission, in light of the number of programs it initiated, could be viewed as a symbol for change in schooling in Australia. Since its demise in 1987, the functions of the Schools Commission have been delegated to the Australian Education Council (AEC). It is this council which oversees the development of national projects.

In his overview of these developments Neil Dempster (1992) comments:

"Action has already extended to rationalising the tertiary education sector, restructuring the awards under which Australia's teachers work, fostering projects that contribute to improving the quality of

teaching and learning and pursuing agreements between Australian education authorities and the Commonwealth Government over a range of matters affecting schooling provision in the States and Territories. Among these matters, recent agreement on the broad purposes of education in Australia by the Australian Education Council set a precedent for common curriculum development activity across the country. In short the Australian Education Council, through the Hobart Declaration, has argued for a sense of national unity, identity and continuity in Australian schools through allegiance to shared curriculum goals."

At its meeting in April 1991, the Australian Education Council approved eight areas of learning as a base for national collaborative curriculum activity :
English, Science, Mathematics,Languages Other Than English (LOTE), The Arts, Technology, Studies of Society and Environment, Health (incorporating physical education and personal development).

The joint funding involves 50% contribution from the Commonwealth and 50% collectively from the States and Territories (according to a weighted formula). Responsibility for the various projects is shared:
Mathematics - New South Wales;
Environmental Education - Victoria;
Science and Studies of Society - Queensland; English - South Australia;
Technology - Tasmania.

For each of these learning areas, a statement will be developed. Hannan (1992) describes them as being *"limited in their scope to a general outline of the main subject matter and skills in the area. Their circulation will also be limited, essentially to curriculum developers in systems and schools rather than to all teachers as though they were some kind of syllabus. Their purpose is twofold: to give a common basis in knowledge and skills for systems and schools across Australia to work from and develop; and to propose new aspects of content where there appear to be gaps in existing State frameworks."* Profile for assessment and reporting, will accompany each statement.

The National Technology Project is one of these areas of learning.

TECHNOLOGY EDUCATION

The literature in the field of Technology is extremely varied, since the development of knowledge and practice in this area has been quite explosive over the last few years.

DEFINING TECHNOLOGY

There are many interpretations of the term "Technology", ranging from the perception of technology as the tools themselves, through to the concept of technology as a process. Many articles about technology refer specifically to the use of computers, videos etc., conceptualising technology as the object produced through technological invention. The more recent articles of the 1980-90's focus on technology as a process, rather than the tool itself. There is no doubt that there is a move towards the perception of technology as the drawing together of knowledge, skills and understanding of technical processes to solve problems and produce a "product".

Jennings-Wray and Wellington (1985) cited in Owen and Chapman (1990) comment:
"There is a tendency for us to think of 'technology as the radio, TV, satellite, or microcomputer. These, however, are simply the embodiment or products of technology. Technology is really the thinking, the rational and creative capacity that man uses to initiate and develop such products. It is not to be confused with the products themselves."

UNESCO (1985) defines technology as: *"...the know-how and creative processes that may assist people to utilise tools, resources and systems to solve problems and to enhance control over the natural and made environments in an endeavour to improve the human condition."* (Rationale: Technology for Australian Schools)

Bail (1986), Brusic (1990), Fleming (1988) and Rainsly and Hughes (1989), comment on the move away from the simplistic view of technology merely as tools. The wider definition is seen by these writers, as not only appropriate, but necessary in order to foster the wider view of technology. It also perceives technology as a social issue - a human issue controlled by humans.

THE TECHNOLOGY CURRICULUM

The Map of Technology in Australian Government Schools (1990) found that learning in technology education emphasised three interdependent aspects - learning ABOUT technologies; learning WITH technologies; learning THROUGH technologies. The Map also found that *"No one definition of technology education is used in all states and territories. A variety of definitions are employed both within and across systems. Each definition reflects the area of the curriculum and the audience for which it is intended."*

Technology in education may embrace every possible means by which information can be presented and the tools used in an educational context. Those with a stake in a particular subject area tend to see technology as the specific tools of that subject. eg the woodwork teacher will see the lathe, jigsaw etc as technology, while the computing studies teacher will perceive computers as technology. Others refer to the technology of education where the principal role of educational technology is to help improve the overall efficiency of the teaching/learning process.

The need to educate students in the skills and capabilities demanded by a rapidly industrialised technological society is recognised by Bolter (1990), Boyd (1988), Chevelier (1990), Jones (1990) Mayer (1992) and Slator (1991), . They have accepted the premise that societies which fail to respond to the economic and social opportunities presented by the technological revolution will be unable to compete effectively on an international level.

A study of current New South Wales syllabus documents shows that some curriculum developers see technology in the curriculum as teaching students about computers, workshop machinery etc, while others emphasise the development of the skills in using such tools as necessary to enhance the move from school to the workplace. Recent syllabus documents (eg Design and Technology) focus on the problem solving skills which will enable students to formulate ideas, put them into practice and foster technological change.

Based on the premise that technology education is an integral part of society and education, researchers (Bolter, 1990; Brusic 1990; Hutchinson and Hutchinson, 1991; Savage and Sterry, 1990;) have provided discussions about the philosophical aspects of technology and the processes needed to teach about it. They include models for technology education - mission, goals, problems, opportunities, resources, assessment, practical implications - and the challenges such models bring to the curriculum.

Harden (1989) refers to the differing philosophical camps which cause conflict in technology education and cite the industrial arts situation as an example. He explains that teachers adhere to the beliefs and traditions that are firmly established in successful pedagogical methodologies which have served them well, slowing in many cases the progress to the 21st century, technology based paradigm. This reinforces the concept proposed by Bolter (1990), Boyd (1988), Chevelier (1990), Jones (1990) and Mayer (1992), that in order to create new opportunities in education for the technical society, curricula decisions can no longer be based on traditions.

Recent developments in technology curriculum build on the widest possible view of technology education, and attempt to incorporate many different aspects - knowledge and skills in technological tools, vocational training, social aspects, economic priorities, creativity, autonomy. However, the issues of choosing appropriate curriculum organisers for the study of technology are often raised, but consensus remains allusive. In general, the literature encourages the move from content or subject based teaching and learning to a variety of educational opportunities and experiences for students, such as thematic learning, problem solving, modular instruction, integrated learning and co-operative learning.

As Savage and Sterry (1990) state:
"the dynamic nature of technology education should reflect the dynamic world of technology..... As our world becomes more technological, and our learners require the ability to make decisions based on intellectual rather than emotional criteria, technology education should enjoy greater visibility."

As our society has developed, it has been necessary to change working ideas or methods - leading to several curricula transitions. A search of the literature has shown that technology is not the sole responsibility of any one subject area, although it is more likely to be included in some subjects - science, mathematics, industrial arts, computing studies - than in others - humanities.

Some curricula link science with technology and adopt the perception that science is the way of knowing, while technology is the way of doing. (NSW Department of School Education: Science and Technology K-6) The emphasis on technology education varies from place to place - one may stress the broader aspect of social issues, while another the use of technology in the classroom.

The research of Bernard and Luundgren (1990) found that technology education is perceived as a "melting pot" for various disciplinary orientations.

Technology and society interact. In developing technology education social issues such as inclusiveness, culture, and values are to be considered, according to the Australian Education Task Force on Education and Technology (1985)

The Guidelines for National Steering Committees state that
"Curriculum statements should recognise that knowledge has been and is developed in a social context. Thus, knowledge in curriculum areas should be defined in a social context. ....Provision should be made in the curriculum for groups with special learning requirements. ....The curriculum should be based on a moral and ethical position. ....Schooling should be an experience which contributes to developing self confidence, respect for others, optimism and high self esteem. ......The curriculum should provide for equality of educational opportunities and recognise that students bring a wide range of abilities and experiences to each area of schooling."

Students need not only to understand various technologies themselves, but how these technologies impact on their lives.

"New technology does not stand alone. It is linked to transformations in real groups of people's lives, jobs, hopes and dreams. For some of these groups, those lives will be enhanced. For others, the dreams will be shattered. Wise choices about the appropriate place of the new technology in education, then, are not only educational decisions. They are fundamentally choices about the kind of society we shall have, about the social and ethical responsiveness of our institutions to the majority of our future citizens." (Owen and Abbott-Chapman, 1990)

NATIONAL TECHNOLOGY PROJECT

The development of the National Technology Project is occurring in a time of rapid change - in society, in education and in technology, as discussed previously. At present we are witnessing a move by the Commonwealth Government to urge the States and Territory Governments to adjust their education policies to meet contemporary nationally based economic imperatives. The federal education portfolio has been restructured within the Department of Employment, Education and Training, promoting the relationship between these three aspects. Within this political environment, the Carmichael, Finn and Meyer Reports demonstrate a very strong support for the inclusion of industry perspectives.

Clarke (1990), in discussing the national perspective towards technology education, takes the view that it provides a catalyst for change - and a change in the right direction.

DEVELOPMENT

A summary of the following initiatives demonstrates the extent and speed of developments in the national curriculum arena. The focus is the Technology Project.

May 1988

Strengthening Australia's Schools: A Consideration of the Focus and Content of Schooling was released by the then Federal Education Minister, John Dawkins. It identified education as part of the "National good"

April 1989

The Hobart Declaration on Schooling, where the Australian Education Council agreed to act jointly to assist Australian schools in meeting the challenges of the times, and developed Common and Agreed National Goals for Schooling in Australia.

January 1990

Establishment of Curriculum Corporation, a company limited by guarantee, owned by the Commonwealth, State and Territory Ministers of Education

February 1990

National K-12 Technology Curriculum Mapping completed

December 1990

Australian Education Council agree to establish a national review of post-compulsory education

April 1991

Upgrading of National Collaborative Curriculum Development Activity providing eight areas of learning for national collaborative activity, to be approved by Australian Education Council. Work on the development of national statements and subject profiles is extended.

July 1991

Finn Report released as part of a national review of post compulsory education and training, proposing six employment-related key competencies to be developed for all young people through a range of pathways.

February and June 1992

Mayer Committee released discussion paper and proposal for discussion, proposing Key Competency Strands, each to be described at a number of performance levels.

March 1992

Carmichael Report released, proposing an integrated system of vocation education and training which would be competency based.

May 1992

National Statement on Technology in Australian Schools released as an Interim Statement

June 1992

CURASS, the Australian Education Council's Curriculum and Assessment Committee is restructured, providing the CURASS Executive with a Secretariate to assist in the process of progressively approving drafts in all learning areas; trialling and validation of profiles; and preparing recommendations to the Australian Education Council Standing Committee.

There are three phases to the National Technology Project:

Phase I - the Mapping (completed)

Phase II - the National Statement 'Technology for Australian Schools' (released as an interim statement)

Phase III - The Technology Profile (at trialling stage)

During Phase I, the project team carried out the request of the Australian Education Council:

- A survey of Technology Education in government systems in all States and Territories, in all areas of the curriculum and all ability ranges was undertaken.
- Information was gathered from policy statements, guidelines, support materials and other forms of documentation as well as from descriptions of practices and projected plans.
- The process used in particular states and territories to collect and collate information varied. The range of people consulted included education administrators, consultants, subject specialists, principals, teachers and in some cases parents and members of the community.
- The survey instrument was designed to collect information on "what is happening" and "what is planned". In conjunction with this the literature review was designed to provide information on "what might happen", derived from emerging national and international trends.
- A preliminary questionaire determined the issues and major areas of concern, and the questions in the survey instrument were developed.

The Brief for Phase 11 states: *"While recognising there are variations both in the stage and nature of development in technology education across the systems, there is a platform of commonality that provides the basis for a second phase of collaborative activity."* The aims for Phase II are listed as:

- to develop a national statement about K-12 technology education in the curriculum
- to describe common curriculum elements around which technology education can be organised
- to describe the kind of learning experiences that should be provided and outcomes achieved in technology education
- to promote further national collaboration on technology education.

Phase III involves the development of a National Technology Profile, to provide an agreed structure for reporting on students' achievements in Technology.

It will :

- develop a share language among Australian teachers for reporting on student achievements
- draw on the work, experiences and expertise of all Australian states and territories in this area of learning.

The profile describes different levels of achievement for students who have followed a program of study that is consistent with the National Statement. It will be used by teachers to determine and report on the level of achievement for individual students in each strand, from year 1 to year 12. Exemplars of learning will be collected from practising teachers to develop the profiles, validation will be conducted by the Australian Council for Educational Research, trialling will occur early 1993, and the Technology Profile is to be released in July 1993.

Some writers have expressed concern at the speed of development. However, I am sure that those who have been involved in the decision making have found the progress slow. If too long is spent in developing the policy, it is out of date before the implementation, but if the time is too short people criticise the speed of change. Is there an acceptable approach? I doubt it.

The development of common and agreed approaches to curriculum is seen by Cumming (1992) and Watkins (1992) to be at odds with the current moves towards school based management. There is definitely some tension between decentralisation at a state level and the centralisation of curriculum at a national level. How this will be reconciled remains to be seen. This issue may become a stumbling block as the project is implemented.

Morris (1992), when discussing parents' perspectives on the National Curriculum, argues that: "teachers will only implement curriculum initiatives faithfully when they are committed to the reforms and they understand the intention behind the changes. .... and that education reform requires community support. Large scale 'top down' curriculum reform does not have a good track record." If the Technology Project is to be successful, the government will need to give thought to marketing the idea. The state leaders have accepted the concept of national curriculum, but can they be sure that the systems will provide the necessary support to teachers? Will the systems provide the *stepping stones* to the teachers, or will they also become a *stumbling block*?

As this national initiative moves from the Australian Education Council, to the states, to the systems, to their regions, to the schools, to the teachers and finally to the students, will it remain intact? There is every chance that unique, but valuable ideas may be lost in the process.

At the last Australian Computers in Education Conference (Melbourne, 1992) a longitudinal design survey was used to collect data from a sampled population. One can make the assumption that the delegates at ACCE have an interest in technology in education. There is no doubt that such a sample represents only a very small percentage of the population, and that they are committed. Although this sample eliminates the ability to generalise, it is accepted that the results give a valid indication of the knowledge of educators who have a stake in the area.

Participants were asked to use a Likert scale to indicate their knowledge of the national statement. A comparison after the statement has been released, will enable a judgement regarding any increase in awareness.

127 participants were surveyed in 1992 and came from the following areas:

primary	22
secondary	44
tertiary	32
consultancy	22
special education	1
research	1

Residential status was as follows:

ACT	5
Victoria	48
New South Wales	25
Tasmania	7
Queensland	12
Western Australia	11
South Australia	15
Northern Territory	4

Participants were asked to rate their knowledge of the statement on the scale of 1 (I have never heard of this document) to 7 (I know this document very well).

75% of the sample selected 1, 2 or 3, demonstrating a very limited knowledge of the statement. It was interesting that 31% had never heard of the national statement. Such a result, leads one to question the effectiveness of the consultancy process during the development of the statement. 15% of the sample selected 5, 6 or 7, with 10% on 4.

Participants in the survey were also asked to select a definition about technology education from a choice of four.

1. *learning to utilise technological tools, resources and systems to solve a variety of problems*
2. *the technological tools that allow students to contribute to the design process*
3. *the purposeful application of knowledge, experience and resources to create processes and products that meet human needs*
4. *teaching about the evolution, application and significance of technological developments*

Despite the lack of knowledge of the document itself, 37% selected the first description of technology education and 46% selected the third description, demonstrating that a majority of those surveyed had an understanding of technology education which relates to that promoted in the national statement.

Judging by reactions at meetings held to explain the national Technology Project, and letters in Professional Group journals, sections of the community have felt excluded from the planning process. However, there is no doubt that a conscious effort was made at a bureaucratic and political level to ensure consultation. Although the intentions are laudable, the size of our country and the time restraints experienced by most educators, will form stumbling blocks. We have all experienced the arrival of a document, requesting feedback within a week; or the short, unreasonable notice of a meeting to discuss issues.

Foggo and Martin (1992) comment that teachers feel excluded from decisions made related to their profession. "While the process may be intended to be collaborative, the agenda is frequently compared to a juggernaut out of control". At public meetings (Australian Council for Computers in Education, July 1992; Technology Education Federation of Australia, December, 1992) educators have expressed concern that this consultation was "too little, too late". Kennedy (1992) expresses the view that "the grudging way in which the educational community has become involved (in the development of national statements) has only served to alienate the educational community"

The need to enhance the collective and individual capacities of groups to respond to national initiatives and policy, resulted in the formation of the National Education Forum in late 1991. We, as technology teachers cannot ignore the national agenda.

Despite Foggo and Martin's (1992) use of the term "bewilderment' to describe the reactions of teachers to the series of changes occurring in the educational environment, they also state that "teachers who have had the opportunity to consider the situation (of national curriculum) have generally come to see the potentially positive aspects".

Although there is criticism about many aspects of national curriculum, Cumming (1992) offers a positive comment: "The concept of a national 'framework', comprising guidelines and principles incorporating sufficient flexibility to embrace the needs and circumstances of local systems and schools seems to be reasonably well-supported at this stage."

In studying the current meaning of national curriculum one must also consider another initiative - that concerned with the development of employment-related competencies inaugurated in the Finn Report (1991) and developed by the Mayer Committee (1991,1992).This is another huge issue, of interest to technology educators, but one which deserves more time and space, than that which is available in this paper.

However, it should be noted that the Mayer Committee (1992) explains that the Key Competency Strands do not, and are not intended to comprise a curriculum, but assume a basis of knowledge. Where knowledge and understandings need to be made explicit, (eg technological understanding), the knowledge base will be provided by the national statements.

THE TECHNOLOGY PROFILE

The issue of assessment and the development of profiles, has initiated much debate. The Profile is designed to be used by teachers (while the Statement has been written for systems), and as such will be of greater interest to the practising teacher.

"The word profile has been used over a long period in the literature on measurement and evaluation in education to describe the presentation of an individual's achievements or characteristics on multiple dimensions." Neil Baumgart cited in Broadfoot (1986).

Boomer (1992) states:

"the subject profile is not itself an instrument of assessment, something which does not appear to be well understood. It is if you like, a vertical map of performance territory from lower to higher performance upon which a student's cumulative performance as assessed can be placed. That is in relation to a nationally or systemically devised set of attainment levels, judgements can be made about present achievement. Each of the levels, or strands within the levels, describes a standard against which the students work can be compared or matched."

The The Further Education Unit (1982) provides further comments about profiles:

"For a common curricula framework, the format of the profile should be common, for unlike many personal records of achievement, profiles are meant to be comparable if they are related to a common curriculum. ...... Profiles, if they are worth using, should be employing a wide and diverse range of assessments."

Broadfoot (1992) discusses the world wide trend for change with regard to assessment. "There is an increasing international concensus that it is important for governments to know what is being learned by students in the education system, and perhaps more significantly, the reasons for the overall strengths and weaknesses in student performance that this monitoring identifies."

UNITED KINGDOM

In the United Kingdom profiles have been developed to meet educational, bureaucratic and parental 'needs', and in conjunction with national curriculum. The Task Group on Assessment and Testing developed an approach which comprised descriptive Attainment Targets, four levels of Standard Assessment Tasks (involving sophisticated national tests and teachers' assessments, individual records), and the publication of schools' results.

Broadfoot (192), Kenway (1992) and Moon (1992) write of the political and educational controversy which surrounds assessment in the United Kingdom.

Kenway (1992) comments that "Major politicians oppose its likely costs, its reliance on teachers' judgements and advocate simple population testing. Teachers oppose the tests, the proposal's costly demands on their time and the publication of results." Moon expands on the clash between teachers and politicians - the idea of short and sharp 'pencil and paper' tests against the quest for more reliable and valid instruments.

The research of Broadfoot (1992) into the impact of assessment of schools in the United Kingdom, points to rapidly declining teacher morale, invidious comparisons between schools, widespread pupil and parent anxiety, and a host of technical difficulties. Kenway (1992) also expresses concern about the 'marketing' aspect inherent in the publication of results by school.

Government policy in the United Kingdom, to separate the curriculum function from the assessment function, under the auspices of two separate national bodies (the National Curriculum Council and the Schools Examinations and Assessment Unit), has led to a degree of 'infighting', according to Broadfoot (1992), Kenway (1992), Medley and White (1992), and Moon (1992).

AUSTRALIA

Boomer (1992) describes subject profiles in the Australian context. They "are, or will be, an integrated part of the officially endorsed curriculum as they are conceived. They have arisen in Australia out of consideration of the various means of assessing and reporting in use. " (p63) He believes they have grown out of " a sense of the inadequacies of other approaches, mainly their effect in narrowing the curriculum, skewing effort in classrooms and denying professional teacher judgement...... The profiles approach comes out of a strongly teacher-centred, classroom-oriented understanding of how judgement works on a day to day basis in our schools." (p64)

The Technology Profile may be described as below:
The progression of student achievement is described over eight levels from year one to year twelve. The levels do not equate with either year levels in school or chronological age of students. The progression of student achievement from level one to level eight represents a continuum of learning in technology.

There are four elements for each level of profile :

- The level statement describes the characteristics of learning at the level by giving a holistic picture of learning across all four strands.
- Outcome Statements describe what students can be expected to achieve in each strand of learning in technology at that level.
- Pointers are typical, not required, examples of student's activities that demonstrate achievement of particular outcomes.
- Work Samples are record samples of student's thoughts and actions that illustrate particular outcomes and pointers.

Together these elements describe student achievement typical of the level. No one element should be interpreted independently of the others. Assessment of student's learning involves making judgements about achievements with all four elements in mind.

Students may achieve at different levels in different strands. A particular student may also display different levels of achievement within different aspects of the same strand.

Australian writers (Boomer, 1992; Kennedy, 1992; McTaggart, 1991; Masters, 1992; Reid, 1992) have debated the advantages and disadvantages associated with the development of national profiles in Australia. They agree that changes have resulted from the notion of 'accountability' which is firmly on the national education agenda, and that the move towards a more relevant method of assessment, is a positive one.

Masters (1992) and Kenway (1992) question how the present assessment methods employed by the states and territories (eg New South Wales Basic Skills Testing Program; Western Australian Monitoring Standards in Education Program), will be linked to the national subject profiles.

McTaggart (1991) uses the Mathematical Profiles Project as an example to demonstrate the lack of time allowed for serious debate during the consultation period. However, the scope of consultation as listed by the Australian Education Council is extensive, and Boomer (1992) is realistic: "While professional associations and sections of the wider community will have had some input into the meta framework, in the final analysis it cannot be an unfiltered new vision." (p64)

Other issues concerning Profiles may be seen as:

- The potential conflict of purposes - one being for the profile to assist teachers in programming and the other being to provide a basis for reporting achievement. The reporting aspect requires a simpler structure than the function of assisting in the development of programs.
- While overall there is little emphasis on content in the profiles strands, some are clearly processes, while others are more concerned with content.
- Relationship between the outcomes in NSW syllabus documents and the national profiles

Each of these issues will affect the technology teachers of today. We must all make an effort to be informed, make judgements, question the changes. But if, as I believe, the national curriculum framework and profiles are here to stay, then I urge you to endeavour to assist in the smooth implementation. It is clear that the Technology Profile will affect the development of curriculum in technology education, and that discussions on its value will continue.

CONCLUSION

The debate concerning national initiatives in Australia, has prompted comment from a number of respected educators. Most of them are critical about the consultation process. However, it is fair to say that, all States and Territories and the Commonwealth have been represented during the development and have reached agreement. It would no doubt be impossible to consult everyone who has a stake in national curriculum, but the lists studied show an expansive network. However, the lack of involvement felt by many is a real issue.

The support provided at the top of the education heirachy is evident in the involvement of the ministers and director generals from each State and Territory. The manner in which it is anticipated that this support will filter down through the systems, to the regions and eventually to the schools and classrooms is not clear at present. The notion of stumbling blocks and stepping stones will no doubt come to the fore when the project is released.

Research into the social and educational setting clarifies the fact that the development of national curriculum, and particularly in the area of technology, is satisfying a need - although a national and international need. The query about the relationships between national curriculum and current syllabus, and profiles and current assessment procedures, will no doubt be prominent during the implementation process.

All the literature studied expounded the belief that technology education will play an important role in the future developments of our society. There are many issues which emerge from a study of the literature. Some of these may be expressed as the following questions:

- Do we need a national curriculum?
- What should it be?
  (The author accepts the fact that these decisions have been made and no amount of research will change them.)
- Will every student be expected to study each of the eight subjects?
- What happens in years 11 and 12?
- How do key competencies fit into the national curriculum?
- Will national profiles become national assessment?
- Will results be published?
- Is there such a thing as typical progress in learning in all aspects of curriculum?
- How do learning and knowledge processes interact?
- Where do the political parties stand?
- What is the relationship between commonwealth and state power?

It is anticipated that you, the reader, will have many other questions. Debate on such issues is healthy as long as the potentially valuable aspects of the national initiative are not lost in the analysis. The importance of technology education, particularly as part of the social, political and economic agendas, cannot be denied. As technology educators, we should accept the National Technology Project, and adapt it to suit the needs and circumstances of our system and school.

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